UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH
Computational Biology and Complex Systems Research Group
CMCiB Comparative Medicine & Bioimage Centre of Catalonia
IGTP Germans Trias i Pujol Research Institute

Daily report 01-06-2020

Analysis and prediction of COVID-19 for EU-EFTA-UK and other countries

Contact: clara.prats@upc.edu

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Foreword

The present report aims to provide a comprehensive picture of the **pandemic situation of COVID-19** in the EU countries, and to be able to foresee the situation in the next coming days.

We employ an **empirical model**, verified with the evolution of the number of confirmed cases in previous countries where the epidemic is close to conclude, including all provinces of China. The model does not pretend to interpret the causes of the evolution of the cases but to permit the **evaluation of the quality of control measures made in each state** and a **short-term prediction of trends**. Note, however, that the effects of the measures' control that start on a given day are not observed until approximately 7-10 days later.

The model and predictions are based on two parameters that are daily fitted to available data:

- ✓ *a*: the velocity at which spreading specific rate slows down; the higher the value, the better the control.
- ✓ *K*: the final number of expected cumulated cases, which cannot be evaluated at the initial stages because growth is still exponential.

We show an individual report with 8 graphs and a table with the **short-term predictions** for different countries and regions. We are adjusting the model to **countries and regions** with at least 4 days with more than 100 confirmed cases and a current load over 200 cases. The **predicted period** of a country depends on the number of datapoints over this 100 cases threshold, and is of 5 days for those that have reported more than 100 cumulated cases for 10 consecutive days or more. For short-term predictions, we assign higher weight to last 3 points in the fittings, so that changes are rapidly captured by the model. The whole methodology employed in the inform is explained in the last pages of this document.

In addition to the individual reports, the reader will find an initial dashboard with a brief analysis of the situation in EU-EFTA-UK countries, some summary figures and tables as well as **long-term predictions** for some of them, when possible. These long-term predictions are evaluated without different weights to data-points. We also discuss a specific issue every day.

Martí Català
Pere-Joan Cardona, PhD
Comparative Medicine and Bioimage Centre of Catalonia; Institute for Health Science Research Germans Trias i Pujol

Clara Prats, PhD
Sergio Alonso, PhD
Enric Álvarez, PhD
Miquel Marchena
David Conesa
Daniel López, PhD
Computational Biology and Complex Systems; Universitat Politècnica de Catalunya - BarcelonaTech

With the collaboration of: Guillem Álvarez, Oriol Bertomeu, Laura Dot, Lavínia Hriscu, Helena Kirchner, Daniel Molinuevo, Pablo Palacios, Sergi Pradas, David Rovira, Xavier Simó, Tomás Urdiales

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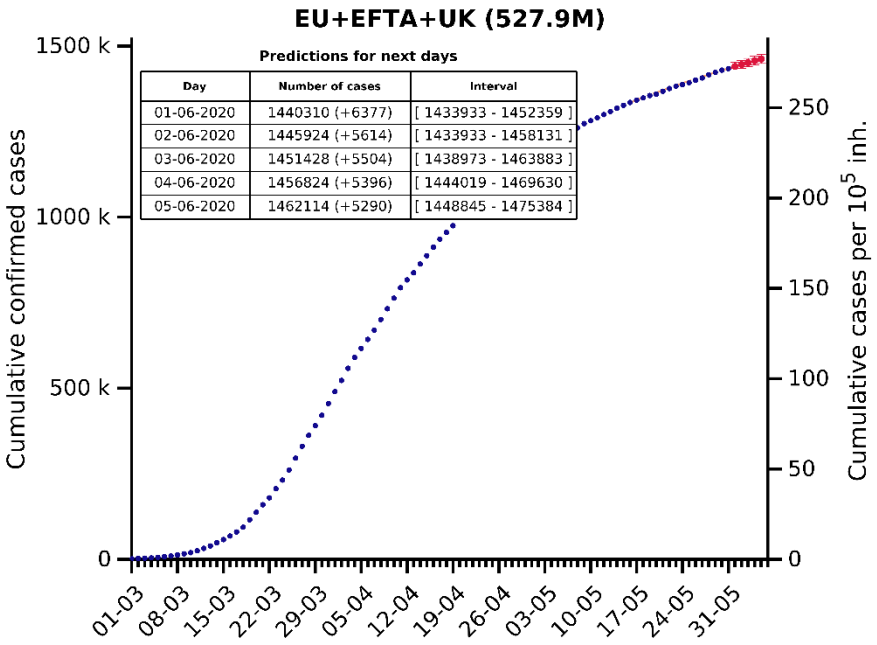
Disclaimer: These reports have been written by declared authors, who fully assume their content. They are submitted daily to the European Commission, but this body does not necessarily share their analyses, discussions and conclusions.

(0) Executive summary – Dashboard

Global EU+EFTA+UK trends and needs

Most of EU+EFTA+UK are consolidating their tail, as reflected by global data. Denmark, Finland and Norway are three of the countries that have handled the pandemic very satisfactorily. We can compare their evolution with Sweden, because of proximity, and with Netherlands, because of size. In both cases, these three countries have controlled the situation much better. If we look at confirmed cases per 100,000 inhabitants. Denmark, Finland and Norway have 201, 138 and 155 respectively. Contrarily, Sweden reports 367 cases per 100,000 inh. and Netherlands report 270. If we consider the average of the three countries, up to date Sweden has had 2.2 times more cases and the Netherlands 1.6.



When looking at the number of deaths per 100,000 inhabitants, the differences are even more significant. Denmark, Finland and Norway have reported 10, 6 and 4 deaths per 10^5 inh, while Sweden and Netherlands have reported 44 and 35, respectively. This indicates that in Sweden there were 6.3 times more deaths than the average of Denmark, Finland and Norway, while in the Netherlands there were 5 times more.

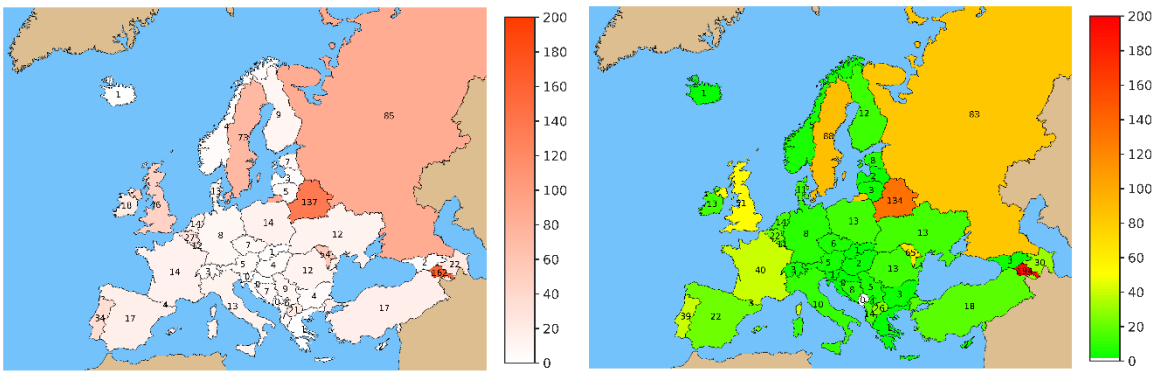
Looking at the evolution in time, it can be said that Finland is where the pandemic has also grown more slowly.

The analysis presents a new scale to measure the situation of countries in the tail, inspired on the Douglas scale of waves in the sea.

Trends for specific countries

The empiric reproduction number (ρ_7) of **France**, **Spain** and **UK** is still affected by a few spikes last week that would not be related with a real increase in incidence. **Sweden** remains at the level of 500-600 daily new cases, without symptoms of starting a decrease. **Poland** seems to be in a similar situation, but at the level of 300-400. **Portugal** is in a compromised situation, since the tail shows a certain trend to increase ($\rho_7 \approx 1.2$). T

The map in the left shows current $\mathbf{A_{14}}$. The map in the right shows current **EPG**.



Situation and trends per country

Table of current situation in EU countries. Colour scale is relative except when indicated, this means that it is applied independently to each column, and distinguishes best (green) form worst (red) situations according to each of the variables. Last column (**EPG_{EST}**) indicates EPG assessed with **estimated real 14-day attack rate** (see report from 22/04 for details). **EPG_{REP}** is calculated with **data reported by countries**. EPG_{REP} and EPG_{EST} **cannot be compared between them** because scales are different, but can be independently used for estimating risk of countries according to reported or estimated real situation, respectively.

	Reported data								Indexes		
Country	Cumulative cases	Attack rate /10^5 inh.	Cumulative deaths	Mortality /10^5 inh.	Active cases (last 14 days)	14-day attack rate /10^5 inh.	Estimated active cases (last 14 days)	Estimated 14-day attack rate /10^5 inh.	ρ_7 [1]	EPG_{REP} [2]	EPG_{EST} [3]
United Kingdom	274,762	413.5	38,489	57.9	31,067	46.8	452,389	666.4	1.12	52	745
Spain	239,429	516.6	27,127	58.5	8,079	17.4	94,298	200.5	1.46	25	292
Italy	233,019	392.1	33,415	56.2	7,584	12.8	110,598	182.9	0.83	11	151
Germany	181,815	222.0	8,511	10.4	7,118	8.7	34,343	41.0	0.97	8	40
France	151,753	234.5	28,802	44.5	9,342	14.4	183,287	280.8	2.76	40	776
Belgium	58,381	514.0	9,467	83.4	3,101	27.3	51,466	444.1	0.81	22	361
Netherlands	46,442	273.4	5,956	35.1	2,447	14.4	31,864	186.0	0.95	14	177
Sweden	37,542	381.6	4,395	44.7	7,399	75.2	95,182	942.5	1.20	90	1,128
Portugal	32,500	313.3	1,410	13.6	3,464	33.4	16,018	157.1	1.16	39	182
Switzerland	30,779	359.1	1,656	19.3	275	3.2	1,515	17.5	1.08	3	19
Ireland	24,990	528.8	1,652	35.0	878	18.6	5,869	118.9	0.73	14	87
Poland	23,786	62.2	1,064	2.8	5,257	13.8	25,637	67.7	0.92	13	62
Romania	19,257	97.4	1,262	6.4	2,386	12.1	16,564	86.1	1.02	12	88
Austria	16,642	191.0	668	7.7	488	5.6	1,998	22.2	0.86	5	19
Denmark	11,669	204.3	574	10.0	742	13.0	3,745	64.7	0.84	11	54
Czech Republic	9,273	87.4	320	3.0	798	7.5	2,837	26.5	0.80	6	21
Norway	8,411	156.7	236	4.4	214	4.0	566	10.4	1.16	5	12
Finland	6,859	124.6	320	5.8	512	9.3	2,613	47.2	1.28	12	60
Luxembourg	4,018	697.6	110	19.1	73	12.7	211	33.7	0.92	12	31
Hungary	3,876	39.7	526	5.4	341	3.5	4,813	49.8	0.62	2	31
Greece	2,917	26.1	175	1.6	83	0.7	529	5.1	0.84	1	4
Bulgaria	2,513	35.2	140	2.0	278	3.9	1,624	23.4	0.70	3	16
Croatia	2,246	53.3	103	2.4	20	0.5	91	2.2	0.50	0	1
Estonia	1,869	142.5	68	5.2	95	7.2	NA	NA	1.10	8	NA
Iceland	1,806	495.8	10	2.7	4	1.1	NA	NA	0.86	1	NA
Lithuania	1,675	57.6	70	2.4	134	4.6	NA	NA	0.69	3	NA
Slovakia	1,522	28.0	28	0.5	28	0.5	NA	NA	1.30	1	NA
Slovenia	1,473	70.9	108	5.2	7	0.3	49	2.4	1.93	1	5
Latvia	1,066	54.1	24	1.2	58	2.9	NA	NA	0.77	2	NA
Cyprus	944	80.7	17	1.5	28	2.4	NA	NA	0.82	2	NA
Malta	616	143.6	7	1.6	63	14.7	NA	NA	NA	NA	NA
Liechtenstein	83	215.3	1	2.6	0	0.0	NA	NA	NA	NA	NA
	Scale										
	Worst	Worst	Worst	Worst	Worst	Worst	Worst	Worst	2.0	100	1000
	Best	Best	Best	Best	Best	Best	Best	Best	0.0	0	0

[1] ρ_7 is the average of 7 consecutive ρ, but can still fluctuate. [2,3] EPG stands for Effective Growth Potential. EPG_{REP} is obtained by multiplying attack rate of last 14 days per 10^5 inhabitants (i.e. density of cases) by ρ_7 (a value related with effective reproduction number and that, therefore, determines the dynamics for subsequent days). EPG_{EST} is obtained by multiplying estimated real attack rate of last 14 days per 10^5 inhabitants by ρ_7.

Highlights for countries with highest number of reported cases

- ✓ Spain is reviewing all historical data, which started showing inconsistencies on mid-May. The government has suggested that the revised series could be published this Wednesday.
- ✓ France's indexes are still affected by Friday's spike.
- ✓ UK, Germany and Italy are following previous trends.
- ✓ These countries are at the level of 2,000 daily new cases (UK), 200-400 (Spain), 400 (Italy) and 300 (Germany). The forecast with France's data is still unreliable.

Analysis: On the need to communicate properly the scale of the epidemics. The Biocom-Cov scale, an adaptation of the Douglas and Richter-like scale (I).

We have been tracking the tail of epidemics in most European countries for the last weeks. Indeed, the epidemics in Europe seems to have stabilized in the last two weeks. As we have explained in the prediction section, we expect a constant number of new cases. This behaviour is not only observed in the European countries as whole, but also in the evolution of individual countries like Austria, Germany, France or Italy. Multiple regions in Spain are also in the same situation. A low background level of new cases appearing each week.

Last mid-April, we precisely discussed how the final stage of the epidemics would look like according to our central scenario. More precisely, the 15th of April assessment was entitled, "And after the peak… what to expect? From the mountain chain to the waving sea"[1].

Right now, **the metaphor of the waving sea is more appropriate than ever since most of the EU+EFTA+UK present oscillation of different magnitude**. It is interesting to classify the different behaviours we encounter in the same way that the waves in earthquakes are classified following the Richter scale or the Douglas scale classifies the wave behaviour of the sea. This type of classification, if properly done, is very useful when there is a need to communicate the real effects of a dangerous situation. We suggest that governments should use a similar scale to communicate the severity of the situation and convey information about what type of measures are required. In this sense, the Richter scale is a very useful example of how, properly used, a good description can help good policy.

In our case, it will be useful to understand the global picture of the epidemiological state in different countries. The discussion regarding the need of a given country to decrease the stable value of the oscillations can be done using a common nomenclature.

The question now is **what is the proper way to classify the different waves of new cases**. In this case, a Richter-type scale where in order to increase from 3 to 4 one needs to increase one order of magnitude the amplitude of the oscillations in the earthquake is not a correct assessment of the situation. A significant change in earthquakes happens when the oscillations increase in a factor 10, here, on the contrary, a change of factor 10 is a huge difference. The difference between something out of control and something that can be properly managed.

In this sense, we found that **the scale used to assess the state of the sea is roughly adequate assess the epidemiological status of oscillations in the incidence of covid-19**. The Douglas scale is based on the characteristic height of the waves. It was defined in 1920 by Captain H.P. Douglas. Conceptually it is easy to understand **the degree of the scale is proportional to the root of the wave height**. This is, a change of factor 2 is amplified by the scale. We can observe here how using the root square gives a proper measure of the situation.

The following table shows the Douglas scale for classifying the waves in the sea.

[1] https://biocomsc.upc.edu/en/shared/20200415_report_web_30.pdf

$$Douglas\ degree \propto \sqrt{wave\ heigth}$$

Degree	Height (m)	Description
0	0	Calm (Glassy)
1	0-0.1	Calm (rippled)
2	0.1-0.5	Smooth
3	0.5-1.25	Slight
4	1.25-2.50	Moderate
5	2.5-4	Rough
6	4-6	Very rough
7	6-9	High
8	9-14	Very high
9	>14	Phenomenal

Douglas scale

This is precisely the type of structure that is needed to describe the gravity of the pandemic situation. We must recall here that we have shown that 200 active new daily cases per 100,000 poses an impossible challenge, while 20 active cases can be dealt by public health officials if they are properly found and the structure of test and trace is in place. Knowing that active cases are those appearing during the last 14 days, we can state that $200 \times 14 = 2{,}800$ is *phenomenal* and very dangerous situation. So, **the beginning of the scale and the final point of the scale can be directly transformed into a pandemic degree if instead of meters we use daily incident cases per 100,000 inhab**.

However, the definition of *very high* in the Douglas scales does not reflect properly the situation in the epidemics. We know from previous reports that 100 active cases per 100,000 inh. is a highly problematic situation. This means that the *very high* degree should start at the equivalent of 7 or 8 daily new cases. We settle for 8. Similarly, 5 daily cases per 100,000 should count as rather high situation and 2 daily cases (around 30 active cases) should be the limit of moderate. With these three ideas in mind, the scale gives a complete and accurate picture of the situation. We introduce the Biocom-Cov scale as:

Pandemic Degree	Daily new incident cases per 10^5 inh.
0	0
1	0-0.1
2	0.1-0.5
3	0.5-1.25
4	1.25-2
5	2-3
6	3-5
7	5-8
8	8-14
9	>14

Biocom-Cov scale

In following reports, we will use this scale to describe the situation of the different countries. We must insist that this scale describes the present situation of the pandemic in each country/region and not the cumulative situation. The Biocom-Cov scale measures the magnitude in the covid-19 pandemic. For other diseases, it will be necessary to define the appropriate values.

Situation and trends in other countries

Table of current situation in a sample of non-EU countries. Colour scale is relative except when indicated, this means that it is applied independently to each column, and distinguishes best (green) form worst (red) situations according to each of the variables. EPG_{REP} and EPG_{EST} **cannot be compared between them** because scales are different, but can be independently used for estimating risk of countries according to reported or estimated real situation, respectively.

	Reported data								Indexes		
Country	Cumulative cases	Attack rate /10^5 inh.	Cumulative deaths	Mortality /10^5 inh.	Active cases (last 14 days)	14-day attack rate /10^5 inh.	Estimated active cases (last 14 days)	Estimated 14-day attack rate /10^5 inh.	ρ_7 [1]	EPG_{REP} [2]	EPG_{EST} [3]
United States of America	1.790.191	540,8	104.383	31,5	303.434	91,7	1.881.261	568,4	0,96	88	546
Brazil	514.849	242,2	29.314	13,8	273.769	128,8	1.925.093	905,7	1,25	160	1.128
Russia	405.843	278,1	4.693	3,2	124.091	85,0	NA	NA	0,98	83	NA
India	190.535	14,1	5.394	0,4	94.366	7,0	320.753	23,7	1,14	8	27
Peru	164.476	498,8	4.506	13,7	72.203	219,0	240.227	728,6	1,40	306	1.017
Iran	151.466	180,3	7.797	9,3	31.268	37,2	171.102	203,7	1,02	38	208
Chile	99.688	521,5	1.054	5,5	55.907	292,5	117.880	616,6	1,09	320	674
Canada	90.936	240,9	7.295	19,3	13.945	36,9	127.243	337,1	0,87	32	292
Mexico	90.664	70,3	9.930	7,7	41.445	32,1	574.087	445,3	1,11	36	496
Saudi Arabia	85.261	244,9	503	1,4	30.509	87,6	NA	NA	0,77	67	NA
Pakistan	72.460	32,8	1.543	0,7	30.335	13,7	76.050	34,4	1,14	16	39
Qatar	56.910	1.975,3	38	1,3	24.306	843,6	NA	NA	1,13	953	NA
Belarus	42.556	450,4	235	2,5	12.906	136,6	NA	NA	0,98	134	NA
Ecuador	39.098	221,6	3.358	19,0	5.916	33,5	58.801	333,3	0,69	23	232
Argentina	16.838	37,3	539	1,2	9.046	20,0	57.220	126,6	1,12	23	142
	Scale										
	Worst	Worst	Worst	Worst	Worst	Worst	Worst	Worst	2,0	100	1000
	Best	Best	Best	Best	Best	Best	Best	Best	0,0	0	0

[1] ρ_7 is the average of 7 consecutive ρ, but can still fluctuate. [2,3] EPG stands for Effective Growth Potential. EPG_{REP} is obtained by multiplying attack rate of last 14 days per 10^5 inhabitants (i.e. density of cases) by ρ_7 (a value related with effective reproduction number and that, therefore, determines the dynamics for subsequent days). EPG_{EST} is obtained by multiplying estimated real attack rate of last 14 days per 10^5 inhabitants by ρ_7.

Disclaimer: estimated active cases and estimated 14-day attack rate are assessed by assuming a lethality of 1 % (see report from 20 to 24 April, #37-41). This value can change in countries where suspicious deaths are reported as well (real values would be lower) and in countries where incidence among elderly people was minor (real values would be higher).

Time indicators by country

These tables summarize a few time indicators for each country: time since 50 cases were reported, time interval between an attack rate of $1/10^5$ inhabitants and an attack rate of $10/10^5$ inhabitants, and time interval between attack rates of 10 to 100 per 10^5 inhabitants (only for countries that have overtaken this threshold).

EU+EFTA+UK countries

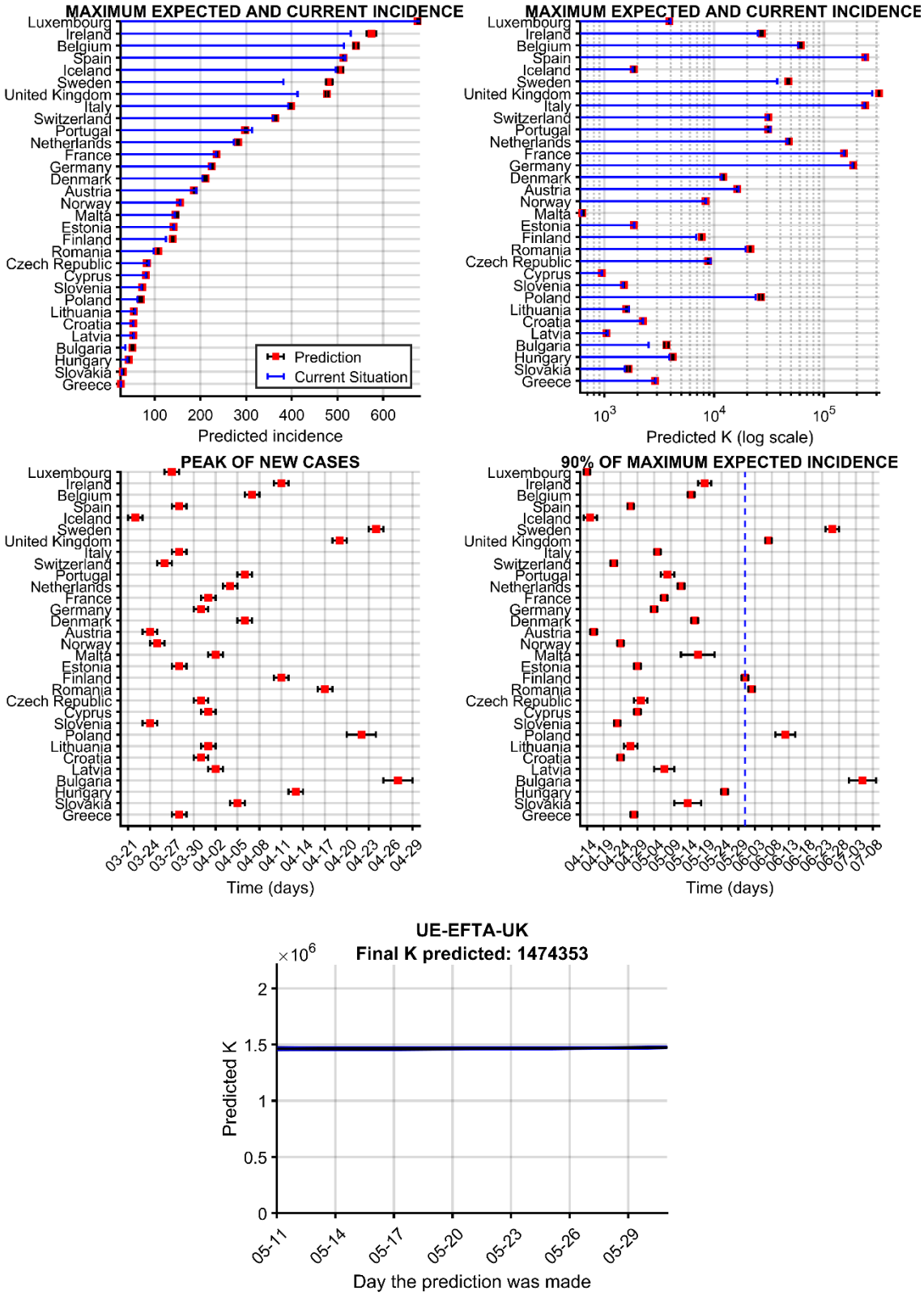
Countries	Days since the first 100 cases	Time interval between 1 and 10 cases / 10^5 inh. (days)	Time interval between 10 and 100 cases / 10^5 inh. (days)
Italy	99	11	16
Germany	93	12	17
France	92	10	20
Spain	92	8	12
United Kingdom	88	10	12
Belgium	87	11	14
Netherlands	87	11	20
Sweden	87	10	28
Norway	87	2	7
Switzerland	87	8	11
Austria	85	10	14
Denmark	84	4	30
Czech Republic	81	11	NA
Finland	81	12	46
Greece	81	18	NA
Iceland	81	5	15
Portugal	80	9	15
Slovenia	80	6	NA
Estonia	79	5	30
Ireland	79	8	18
Poland	79	17	NA
Romania	79	15	NA
Luxembourg	76	6	7
Slovakia	75	24	NA
Bulgaria	74	30	NA
Croatia	74	12	NA
Hungary	73	20	NA
Latvia	73	12	NA
Lithuania	72	9	NA
Malta	71	9	35
Cyprus	70	12	NA

Other countries

Countries	Days since the first 100 cases	Time interval between 1 and 10 cases / 10^5 inh. (days)	Time interval between 10 and 100 cases / 10^5 inh. (days)
Iran	96	11	42
United States of America	91	8	15
Canada	82	11	27
Qatar	82	3	31
Brazil	79	20	34
Saudi Arabia	78	21	29
Chile	77	13	36
Pakistan	77	35	NA
India	77	38	NA
Russia	76	15	24
Peru	76	18	22
Ecuador	76	10	30
Mexico	75	25	NA
Argentina	74	39	NA
Belarus	63	10	18

Long-term predictions

Evaluated with the **whole historical series**. See figure in the next page. Up-left: Predictions of maximum incidences per country (total final expected attack rate per 10^5 inh.). Up-right: Predictions of maximum absolute number of cases per country (K, in log scale). Blue lines indicate current situation. Bottom-left: Time in which peak in new cases was achieved / will be achieved. Bottom-right: Time at which 90 % of K was achieved / will be achieved. Blue dotted line indicates current date. At the end, predicted K for whole EU+EFTA+UK.



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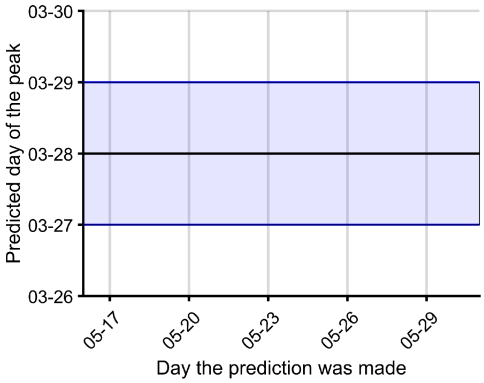
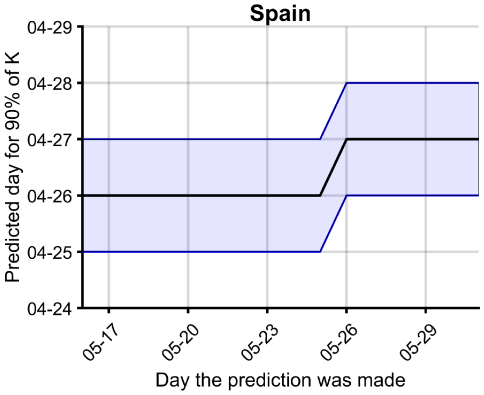
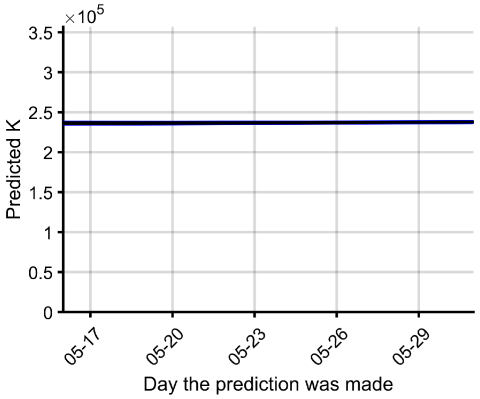
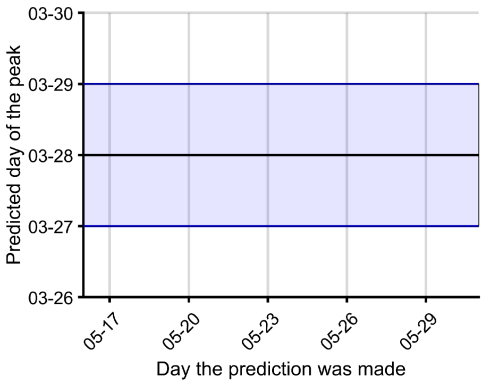


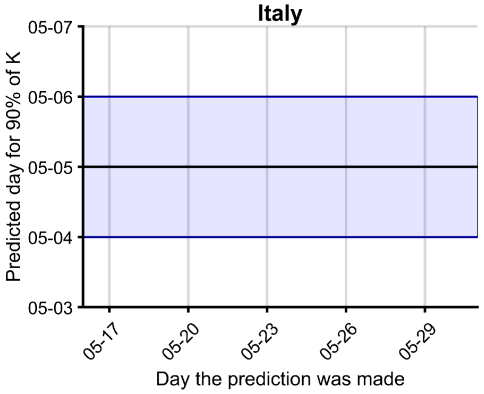
Spain

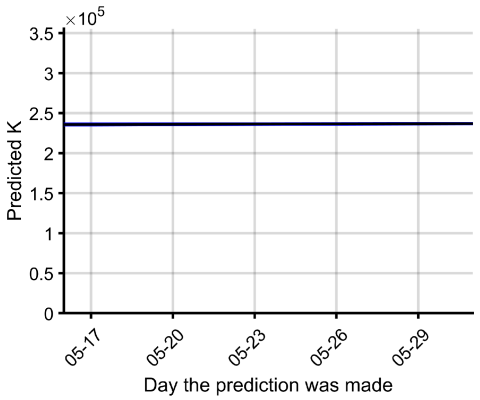


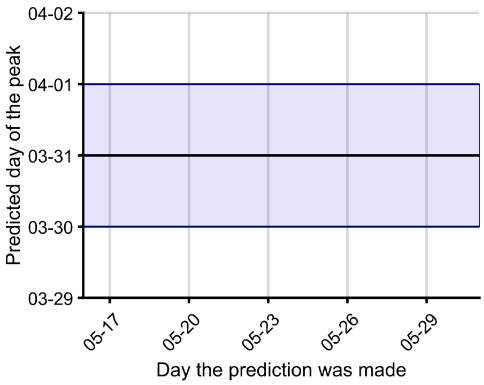




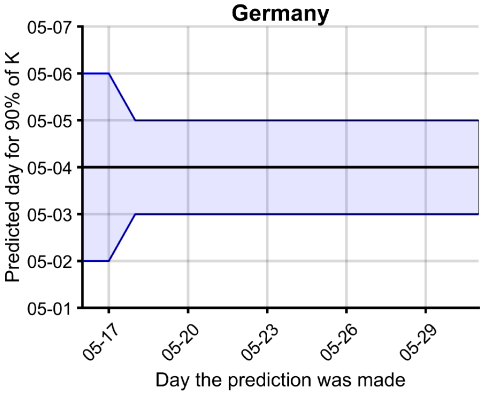
Italy

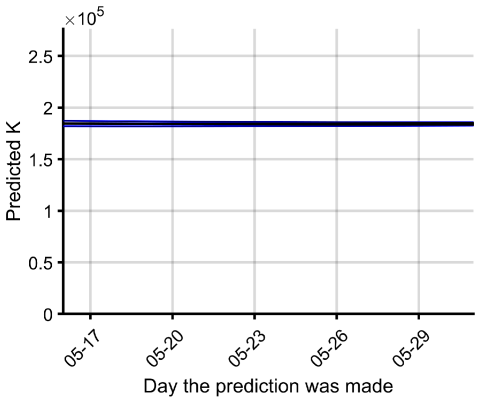


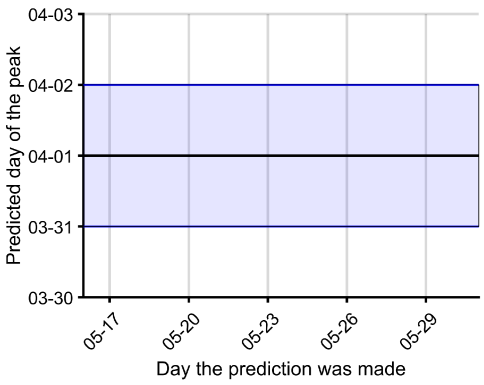




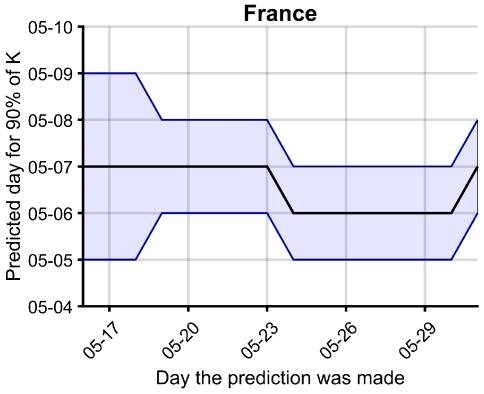
Germany

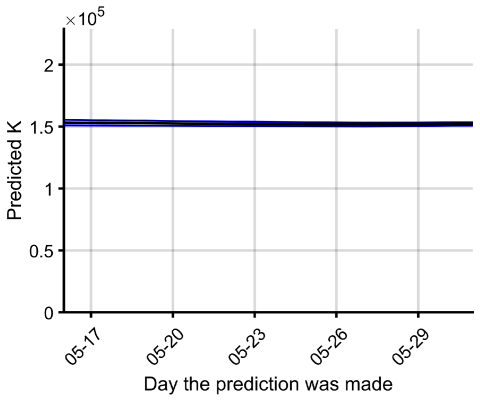


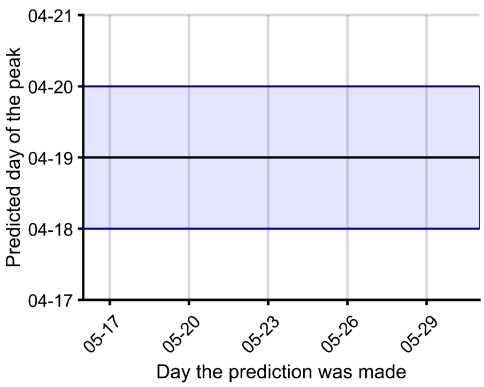




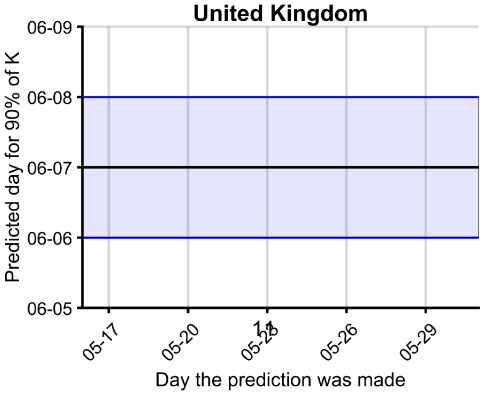
France

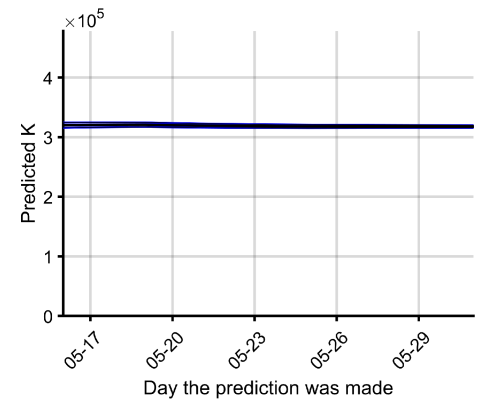






United Kingdom





Situation and trends in Italian regions[2]

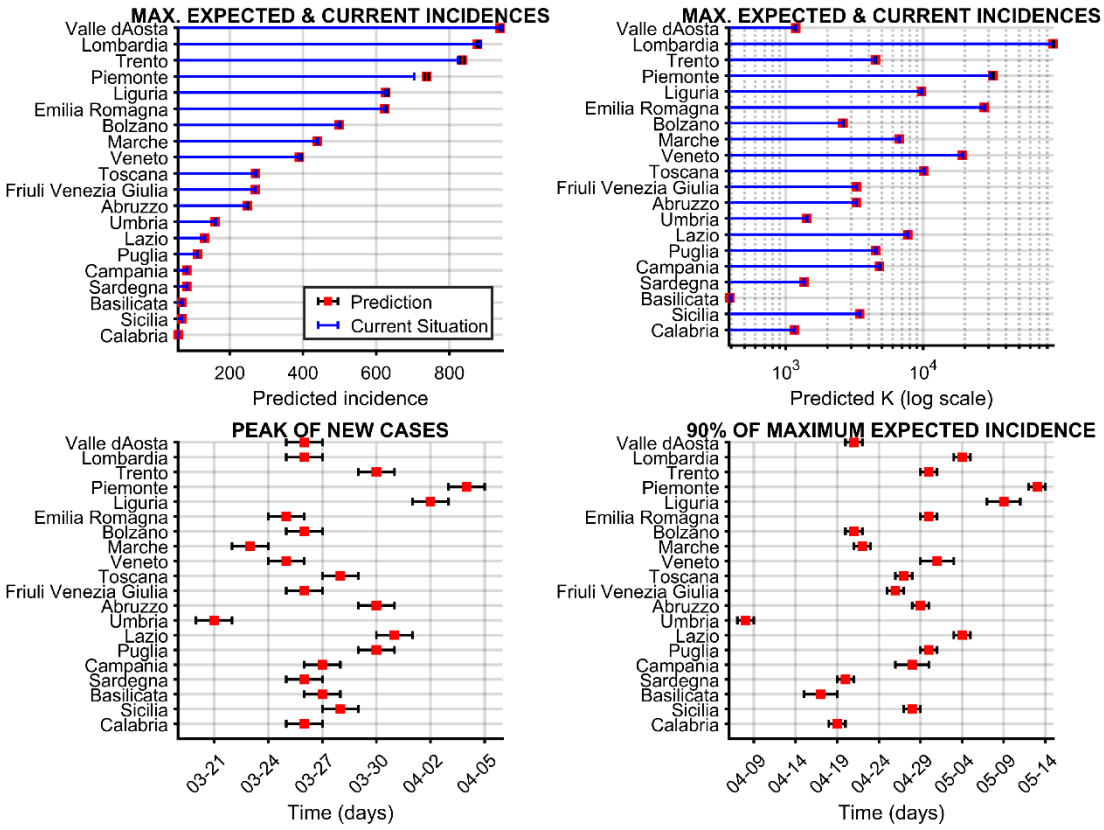
Situation and trends

	Reported data								Indexes		
Country	Cumulative cases	Attack rate /10^5 inh.	Cumulative deaths	Mortality /10^5 inh.	Active cases (last 14 days)	14-day attack rate /10^5 inh.	Estimated active cases (last 14 days)	Estimated 14-day attack rate /10^5 inh.	ρ_7 [1]	EPG_{REP} [2]	EPG_{EST} [3]
Lombardia	89.018	886,5	16.131	160,6	3.999	39,8	71.792	713,6	0,92	36	654
Piemonte	30.658	703,7	3.876	89,0	1.039	23,8	12.994	298,3	0,87	21	258
Emilia Romagna	27.809	623,6	4.124	92,5	542	12,2	8.037	180,2	0,83	10	150
Veneto	19.154	390,4	1.918	39,1	204	4,2	1.940	39,5	0,65	3	26
Toscana	10.107	271,0	1.048	28,1	146	3,9	1.567	42,0	0,54	2	23
Liguria	9.719	626,8	1.467	94,6	528	34,1	7.946	512,3	0,70	24	357
Lazio	7.738	131,6	739	12,6	253	4,3	2.562	43,6	0,68	3	29
Marche	6.730	441,2	987	64,7	52	3,4	851	55,8	0,70	2	39
Campania	4.806	82,8	413	7,1	111	1,9	964	16,6	0,89	2	15
Puglia	4.498	111,6	506	12,6	112	2,8	1.254	31,1	0,52	1	16
Trento	4.432	413,3	462	43,1	81	7,6	865	160,7	0,50	4	80
Sicilia	3.443	68,9	274	5,5	48	1,0	380	7,6	0,83	1	6
Friuli Venezia Giulia	3.274	269,4	335	27,6	76	6,3	794	65,4	0,82	5	54
Abruzzo	3.245	247,4	408	31,1	52	4,0	667	50,8	0,56	2	29
Bolzano	2.598	2.418,2	291	270,9	16	14,9	170	32,7	0,90	13	29
Umbria	1.431	162,2	76	8,6	7	0,8	NA	NA	0,15	0	NA
Sardegna	1.357	82,8	131	8,0	4	0,2	36	2,2	0,00	0	0
Valle dAosta	1.187	945,0	143	113,8	13	10,3	157	124,8	1,24	13	155
Calabria	1.158	59,5	97	5,0	7	0,4	NA	NA	0,32	0	NA
Molise	436	142,7	22	7,2	14	4,6	NA	NA	0,52	2	NA
Basilicata	399	70,9	27	4,8	7	1,2	NA	NA	0,07	0	NA
	Scale										
	Worst	Worst	Worst	Worst	Worst	Worst	Worst	Worst	2,0	100	1000
	Best	Best	Best	Best	Best	Best	Best	Best	0,0	0	0

[1] ρ_7 is the average of 7 consecutive ρ, but can still fluctuate. [2,3] EPG stands for Effective Growth Potential. EPG_{REP} is obtained by multiplying attack rate of last 14 days per 10^5 inhabitants (i.e. density of cases) by ρ_7 (a value related with effective reproduction number and that, therefore, determines the dynamics for subsequent days). EPG_{EST} is obtained by multiplying estimated real attack rate of last 14 days per 10^5 inhabitants by ρ_7.

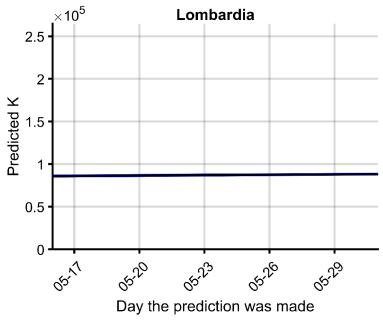
Disclaimer: estimated active cases and estimated 14-day attack rate are assessed by assuming a lethality of 1 % (see report from 20 to 24 April, #37-41). This value can change in countries where suspicious deaths are reported as well (real values would be lower) and in countries where incidence among elderly people was minor (real values would be higher).

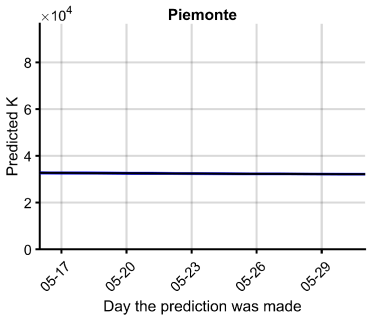
Long-term predictions

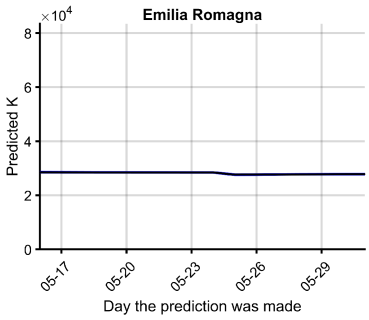


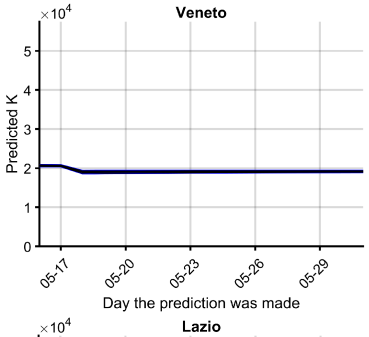
[2] **Spain:** Historical series have not been updated. Therefore, regional analysis is not shown

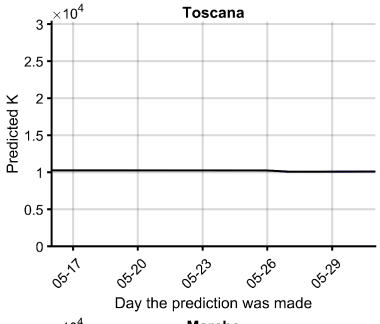
2020-06-01

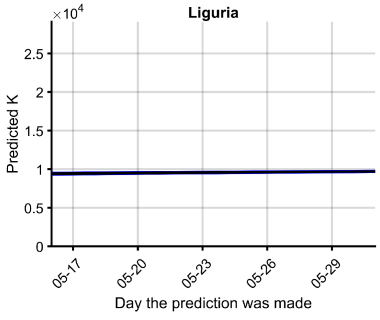

Lombardia
×10^5
Predicted K
Day the prediction was made
05-17
05-20
05-23
05-26
05-29

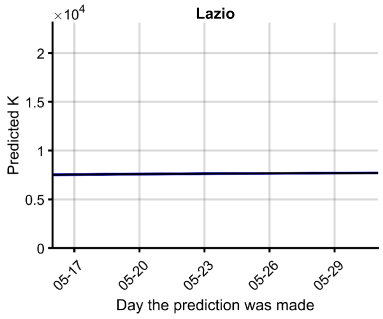

Piemonte
×10^4
Predicted K
Day the prediction was made
05-17
05-20
05-23
05-26
05-29

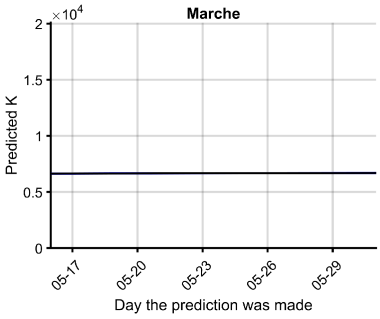

Emilia Romagna
×10^4
Predicted K
Day the prediction was made
05-17
05-20
05-23
05-26
05-29

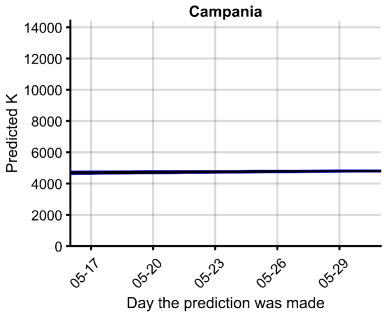

Veneto
×10^4
Predicted K
Day the prediction was made
05-17
05-20
05-23
05-26
05-29

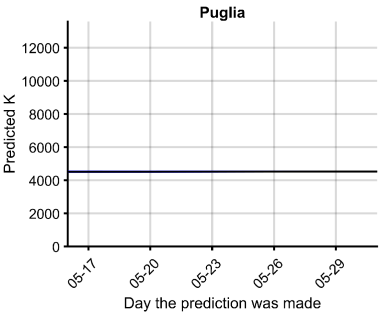

Toscana
×10^4
Predicted K
Day the prediction was made
05-17
05-20
05-23
05-26
05-29

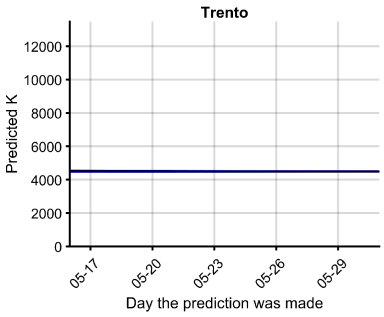

Liguria
×10^4
Predicted K
Day the prediction was made
05-17
05-20
05-23
05-26
05-29

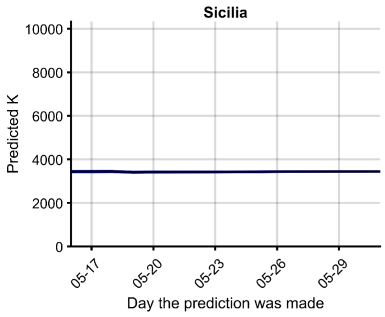

Lazio
×10^4
Predicted K
Day the prediction was made
05-17
05-20
05-23
05-26
05-29

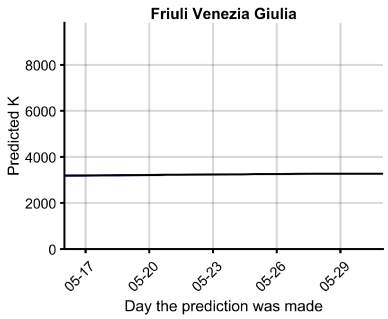

Marche
×10^4
Predicted K
Day the prediction was made
05-17
05-20
05-23
05-26
05-29

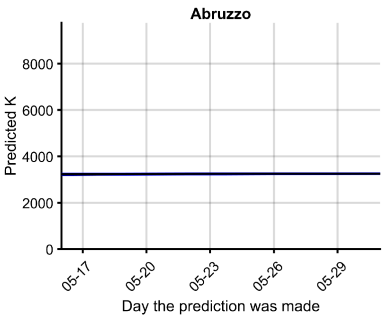

Campania
Predicted K
Day the prediction was made
05-17
05-20
05-23
05-26
05-29

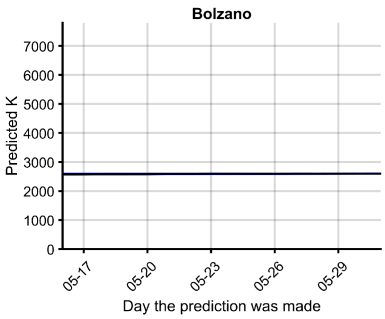

Puglia
Predicted K
Day the prediction was made
05-17
05-20
05-23
05-26
05-29

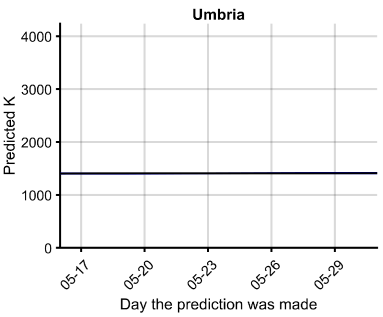

Trento
Predicted K
Day the prediction was made
05-17
05-20
05-23
05-26
05-29

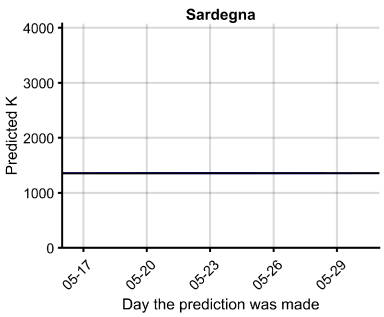

Sicilia
Predicted K
Day the prediction was made
05-17
05-20
05-23
05-26
05-29

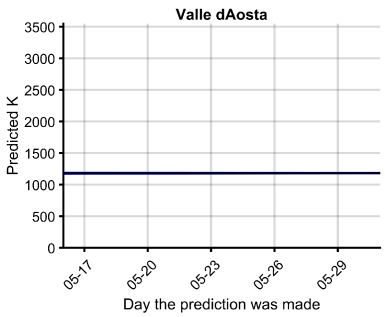

Friuli Venezia Giulia
Predicted K
Day the prediction was made
05-17
05-20
05-23
05-26
05-29

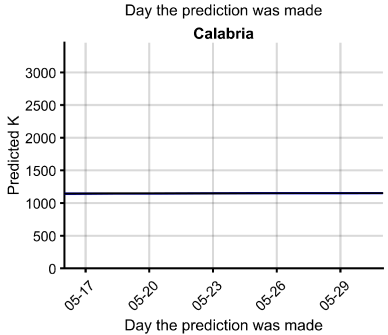

Abruzzo
Predicted K
Day the prediction was made
05-17
05-20
05-23
05-26
05-29

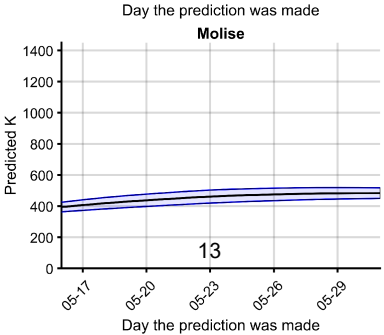

Bolzano
Predicted K
Day the prediction was made
05-17
05-20
05-23
05-26
05-29

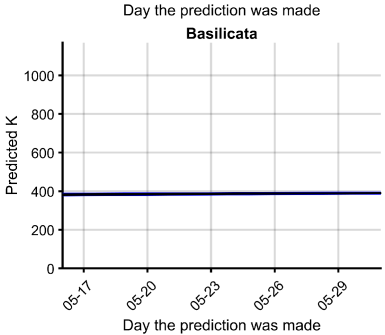

Umbria
Predicted K
Day the prediction was made
05-17
05-20
05-23
05-26
05-29


Sardegna
Predicted K
Day the prediction was made
05-17
05-20
05-23
05-26
05-29


Valle dAosta
Predicted K
Day the prediction was made
05-17
05-20
05-23
05-26
05-29

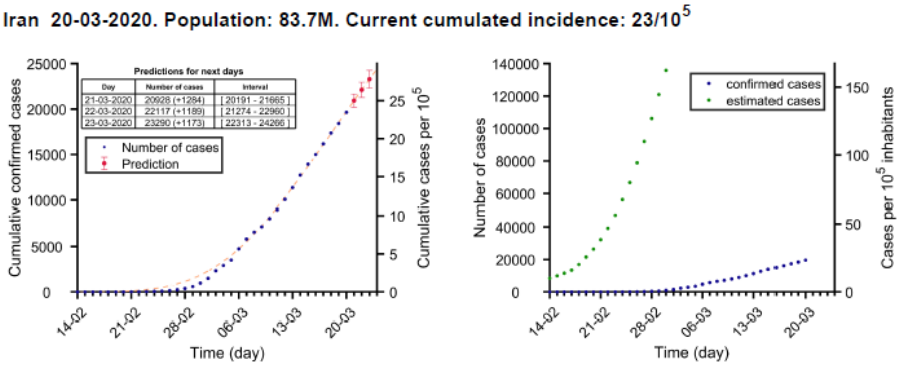

Calabria
Predicted K
Day the prediction was made
05-17
05-20
05-23
05-26
05-29


Molise
Predicted K
Day the prediction was made
05-17
05-20
05-23
05-26
05-29


Basilicata
Predicted K
Day the prediction was made
05-17
05-20
05-23
05-26
05-29

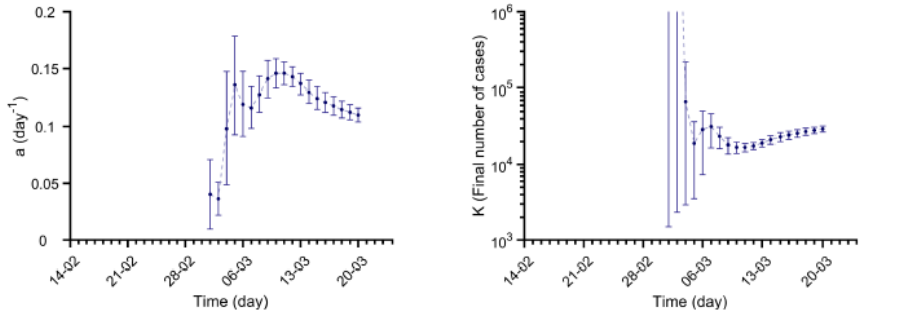
Legend: Countries' reports details

Confirmed cases: data (blue), model fitted (dashed line), predictions (red points and table)



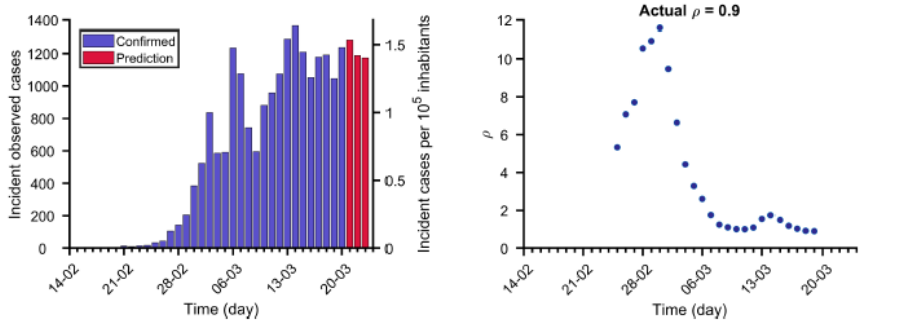
Estimated cases using death rate (see Methods)

Fitted *a* value using points prior to each date



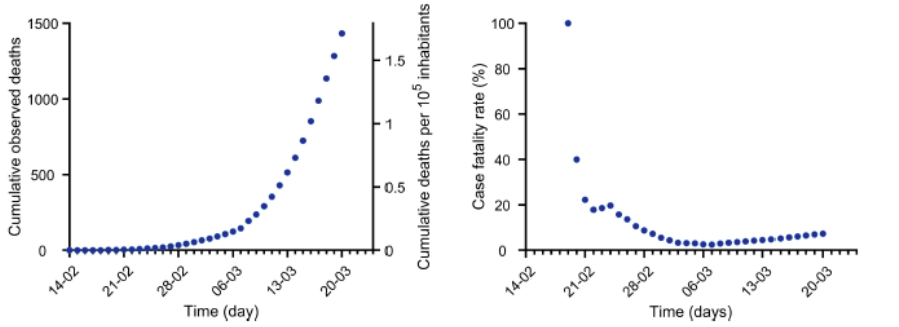
Fitted *K* value using points prior to each date

Reported and predicted new cases



Evolution of ρ, a parameter related with Reproduction number (see Methods)

Reported deaths

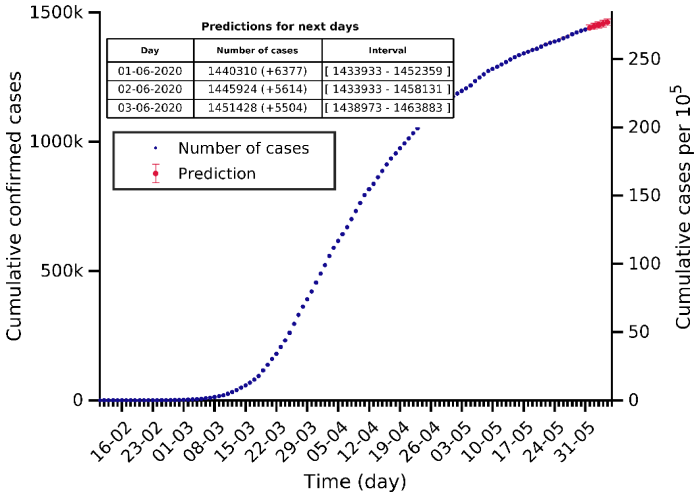


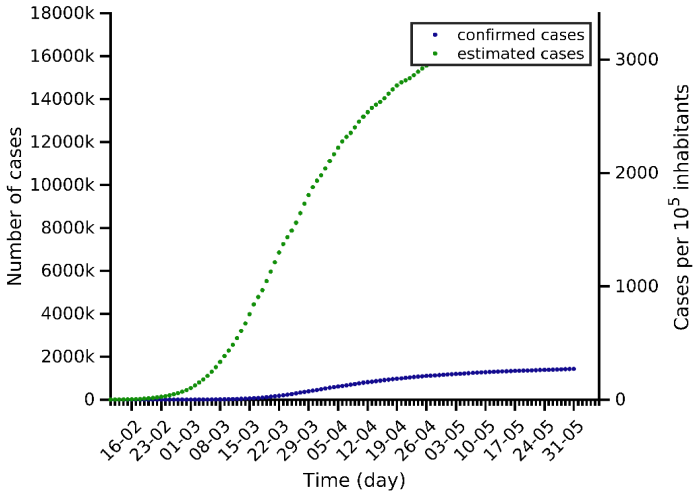
Deaths / cumulated reported cases

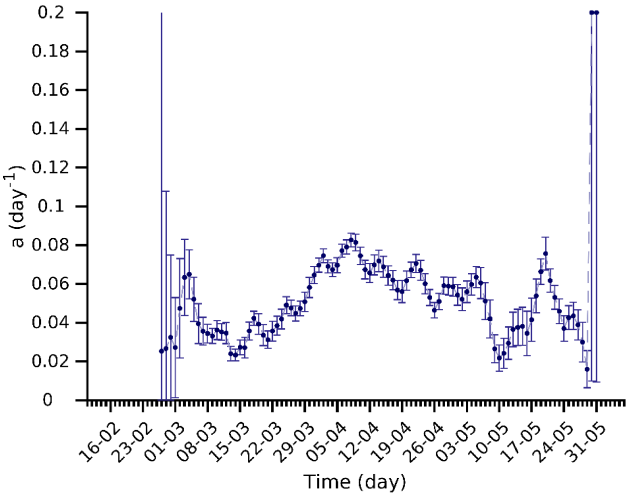
(1) Analysis and prediction of COVID-19 for EU+EFTA+UK

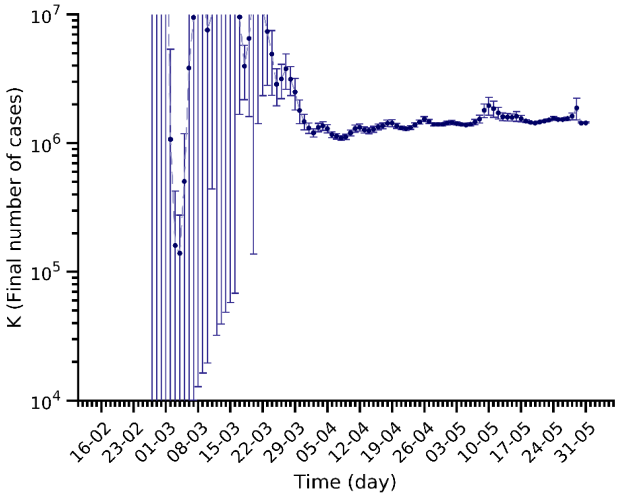
Data obtained from https://www.ecdc.europa.eu/en/geographical-distribution-2019-ncov-cases

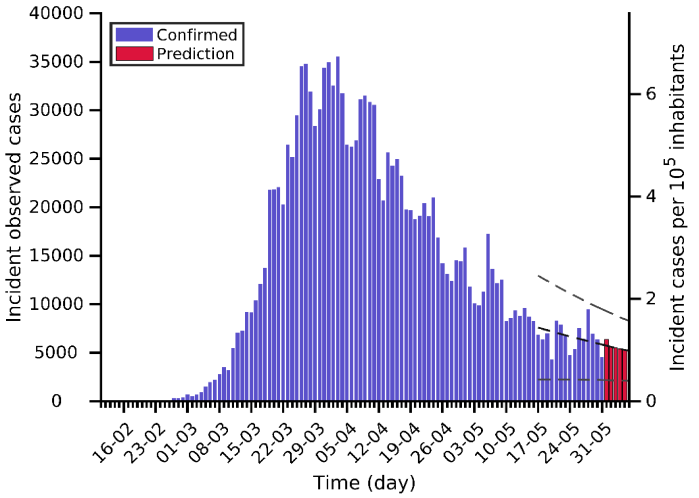
EU+EFTA+UK 31-05-2020. Population: 527.9M. Current cumulated incidence: 272/1

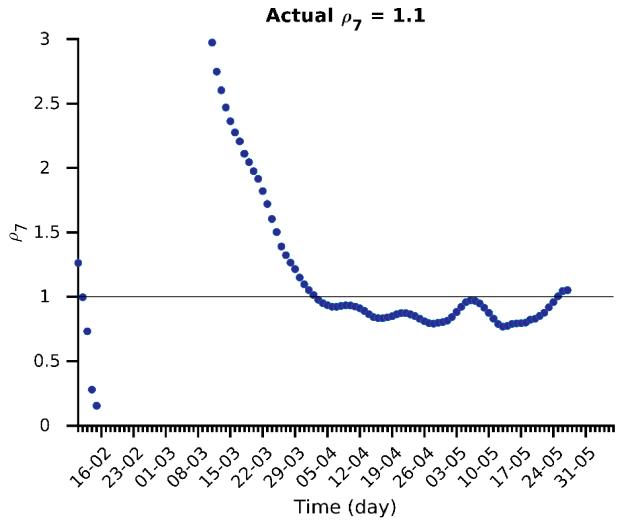


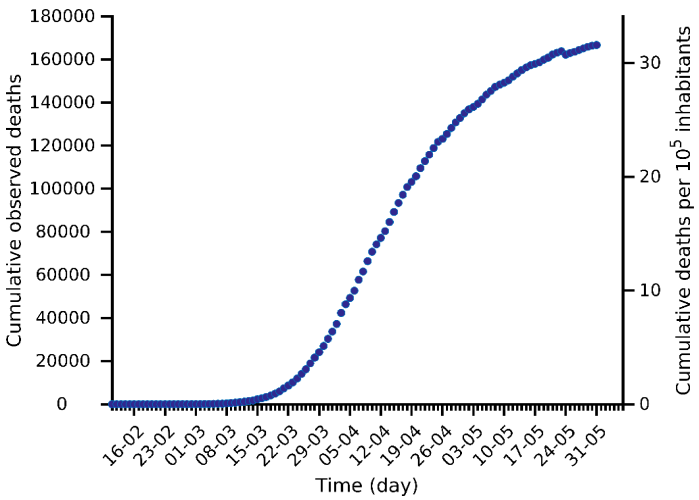


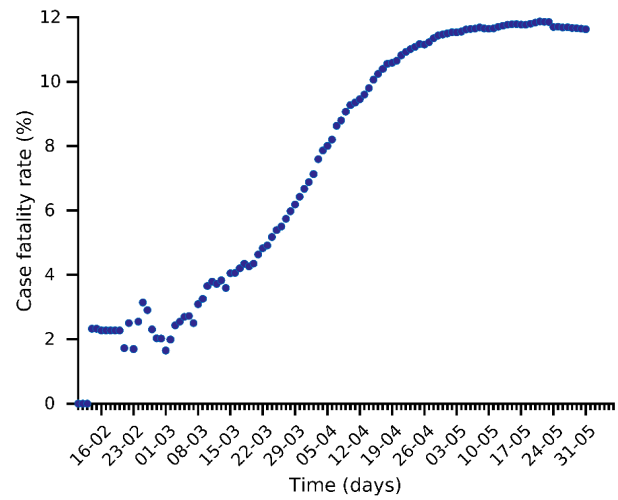




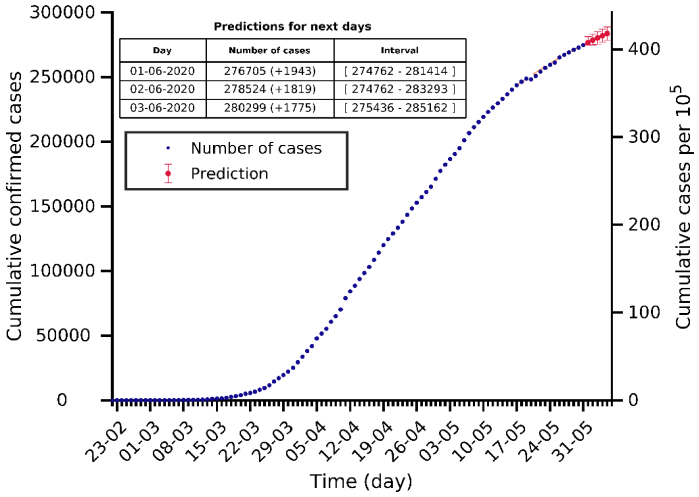


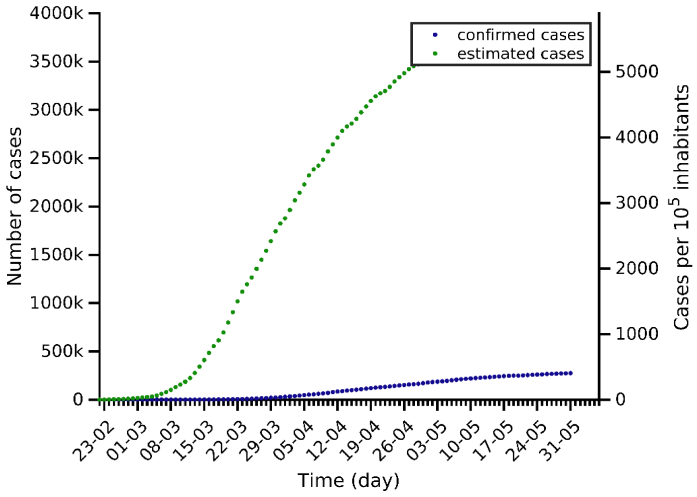


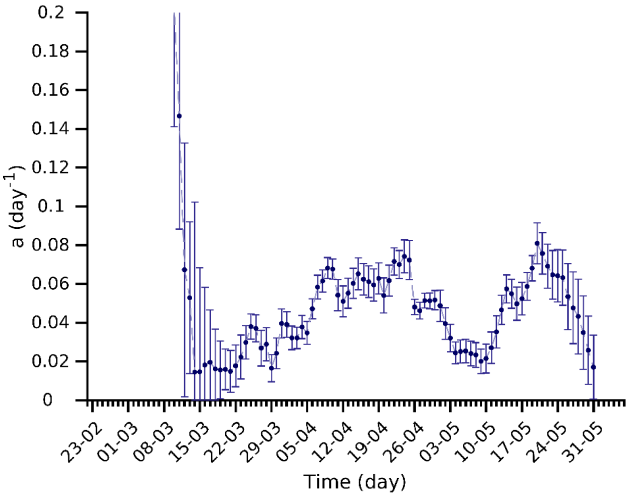


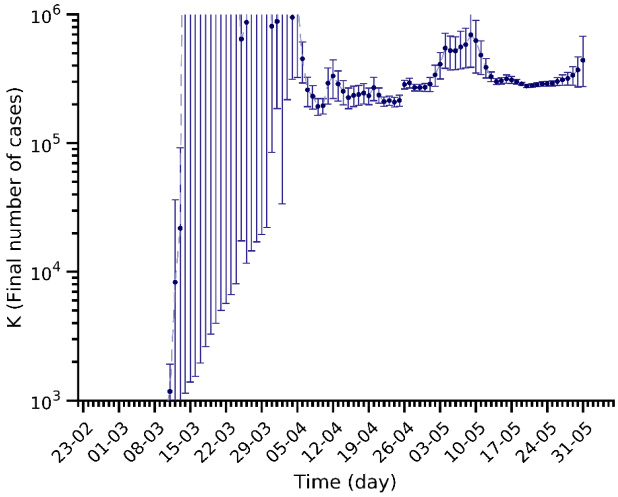


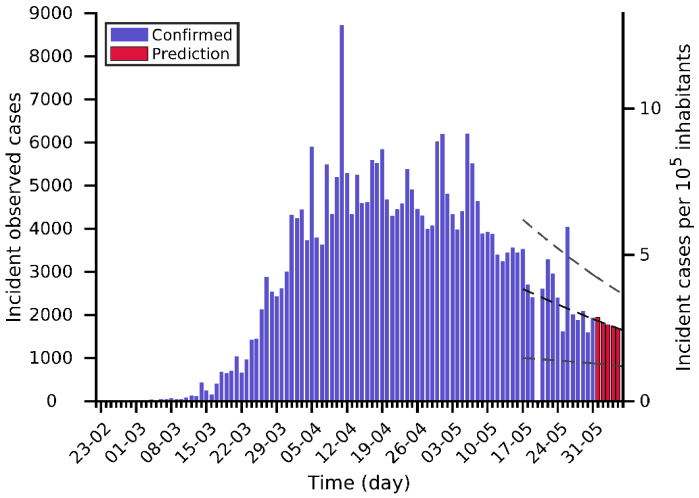
UK 31-05-2020. Population: 67.9M. Current cumulated incidence: $405/10^5$

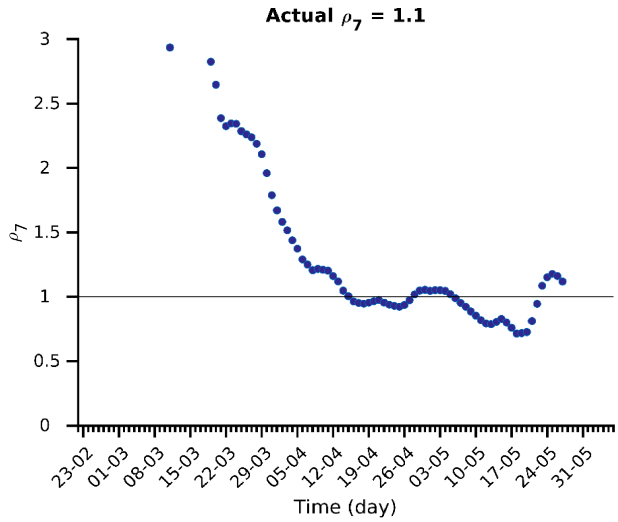


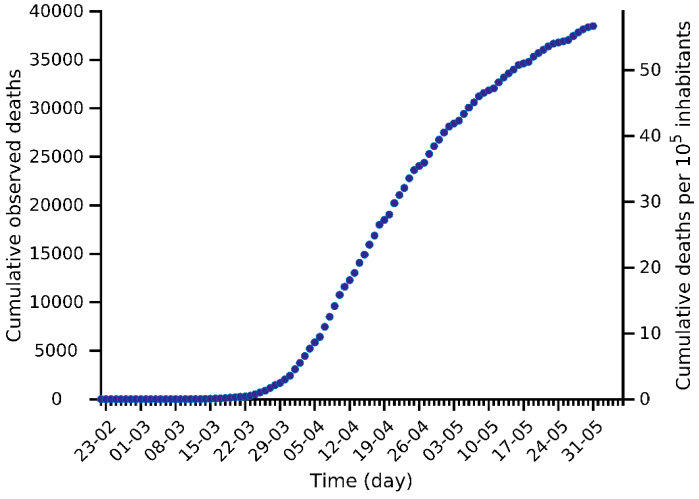


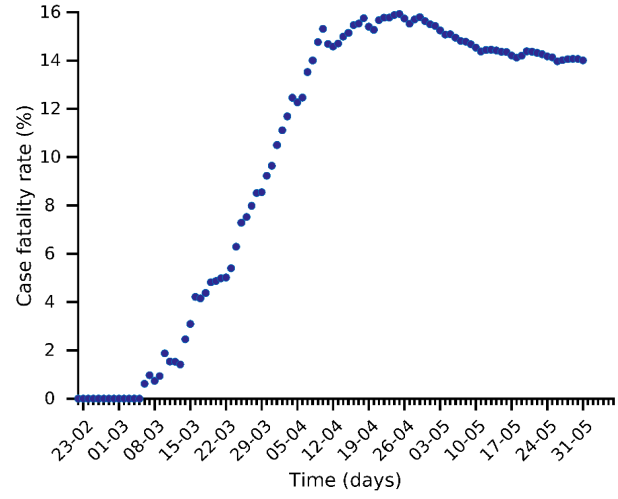




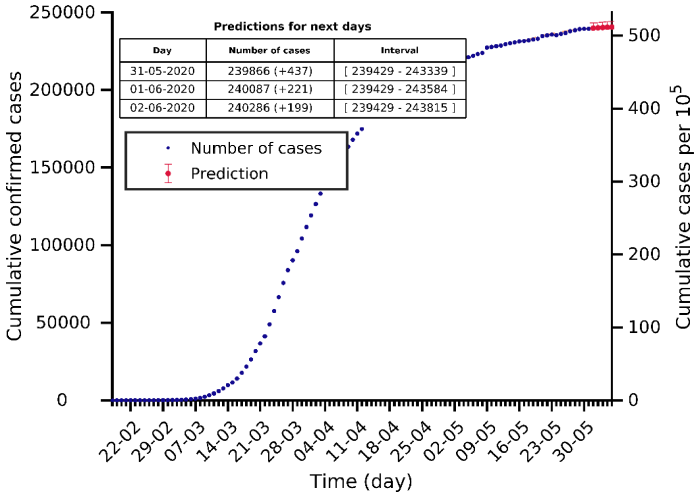


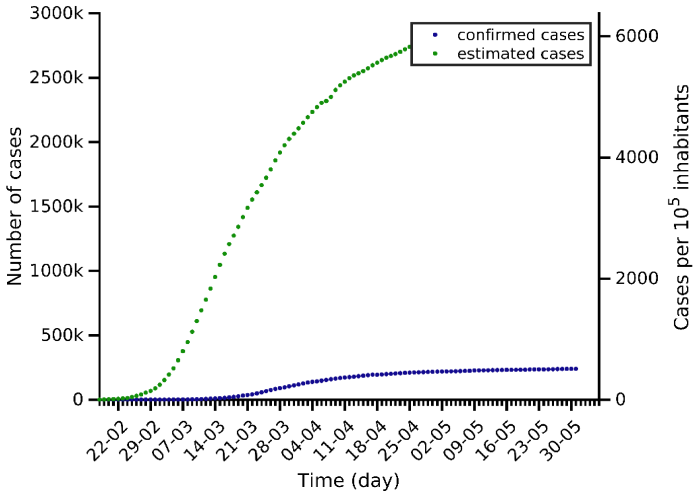


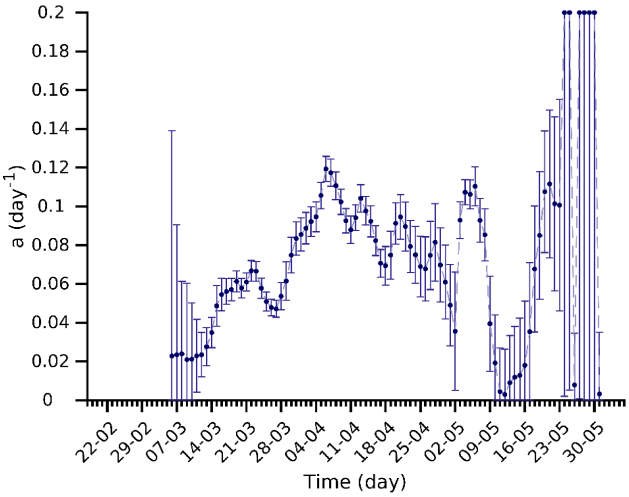


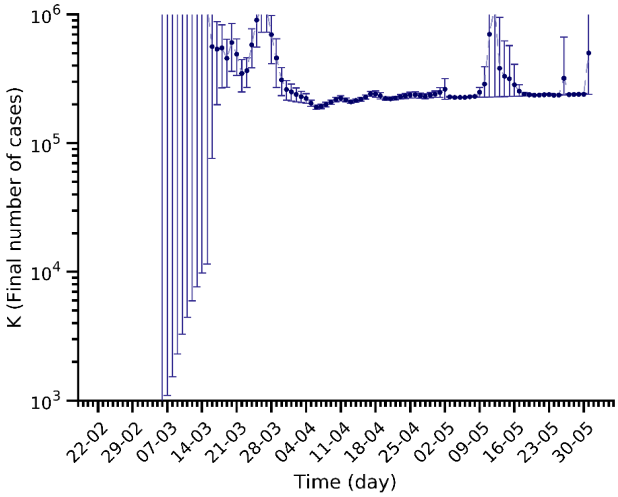


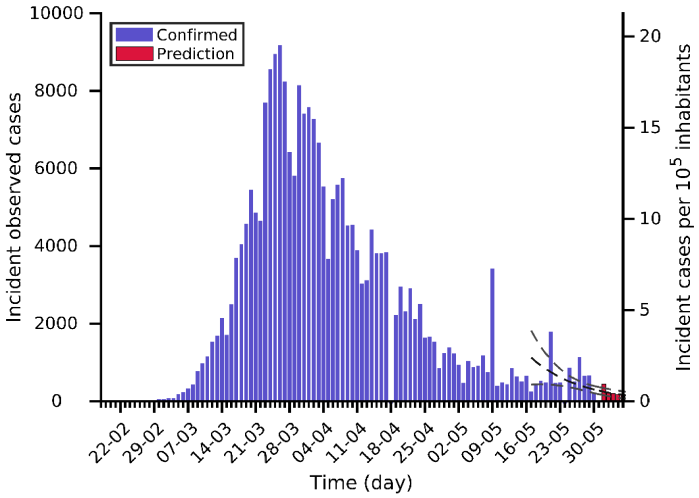
Spain 30-05-2020. Population: 47.0M. Current cumulated incidence: 509/10⁵

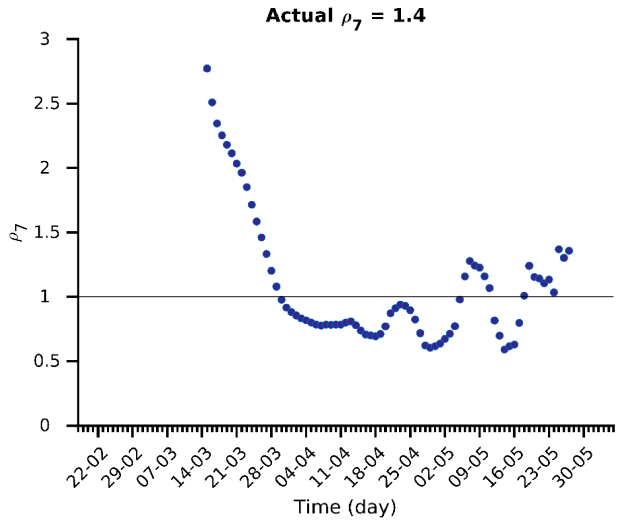


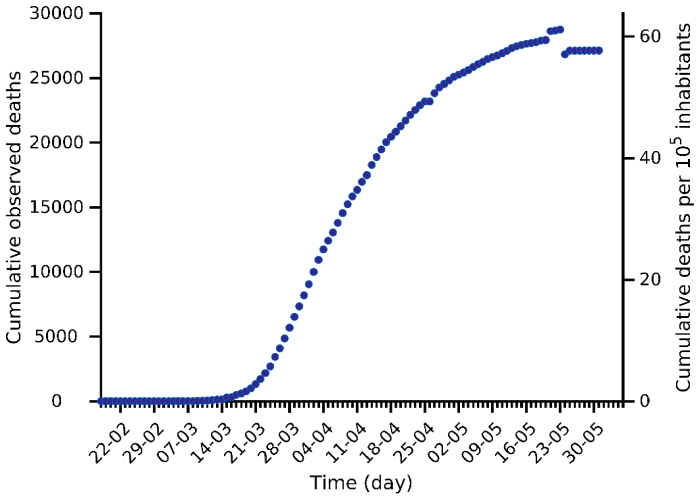


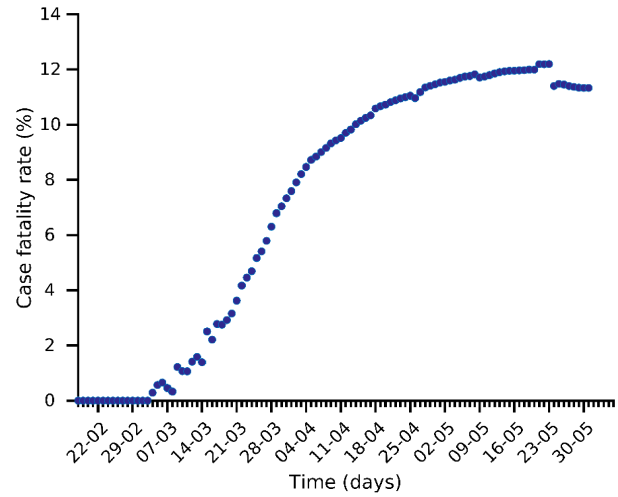




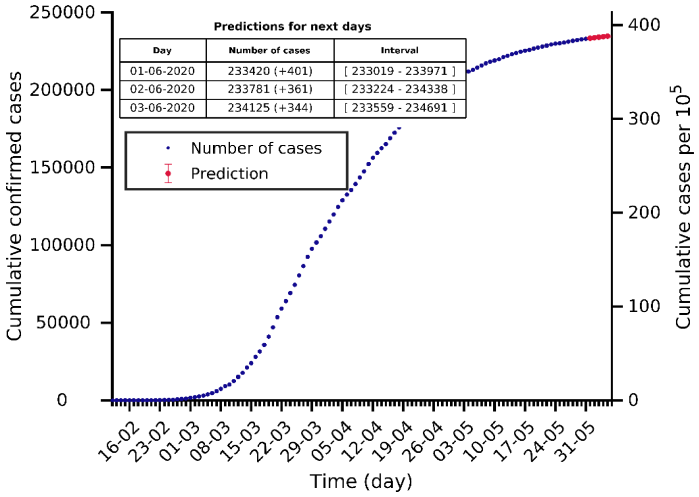


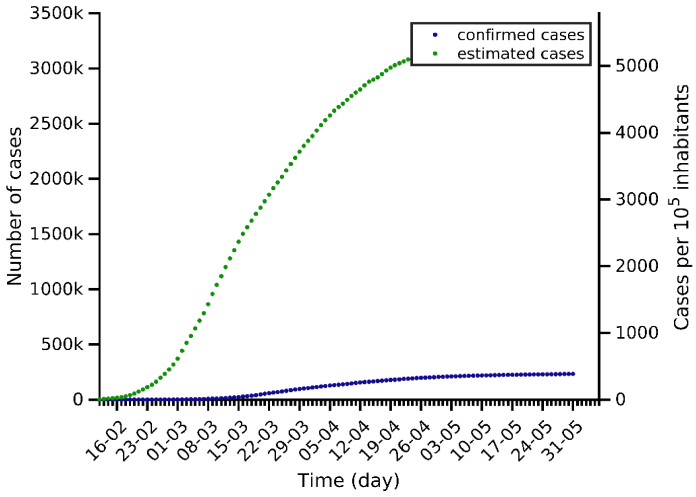


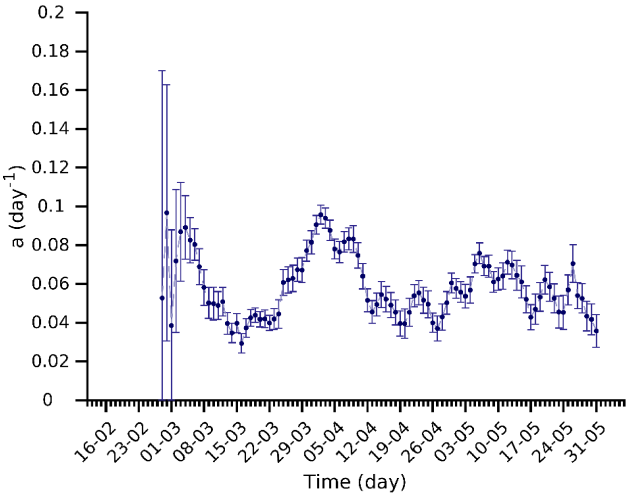


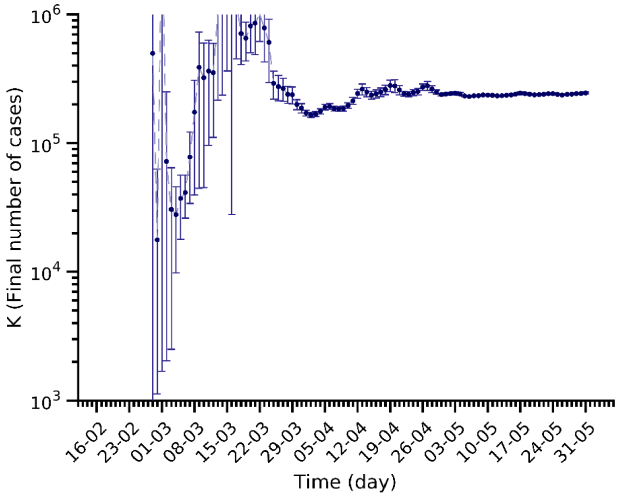


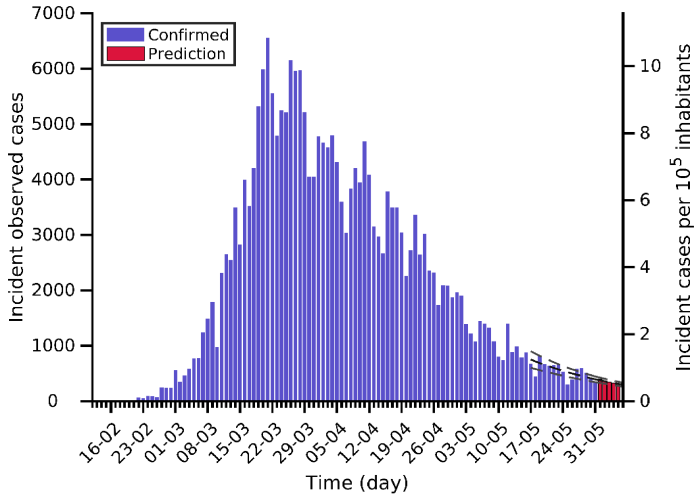
Italy 31-05-2020. Population: 60.5M. Current cumulated incidence: $385/10^5$

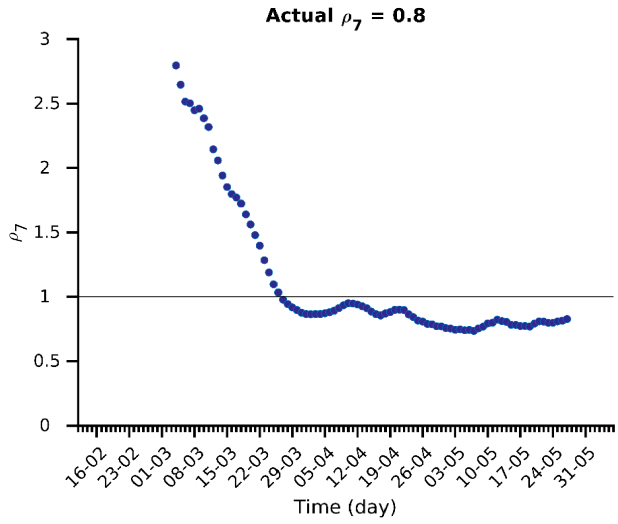


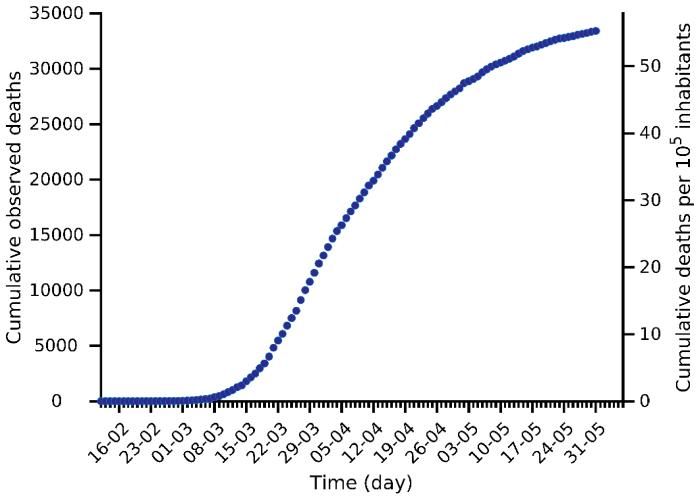


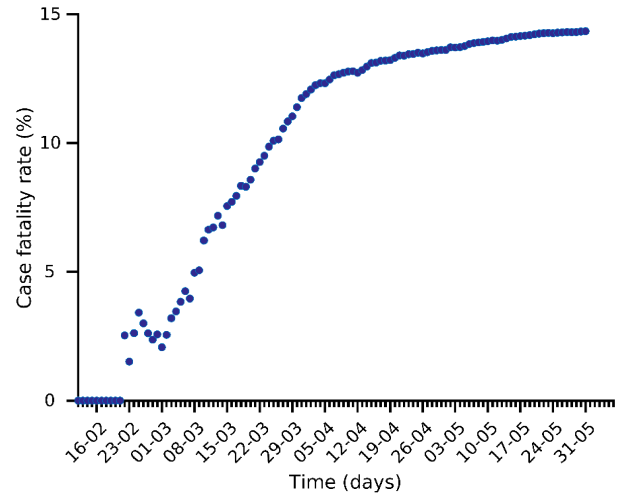




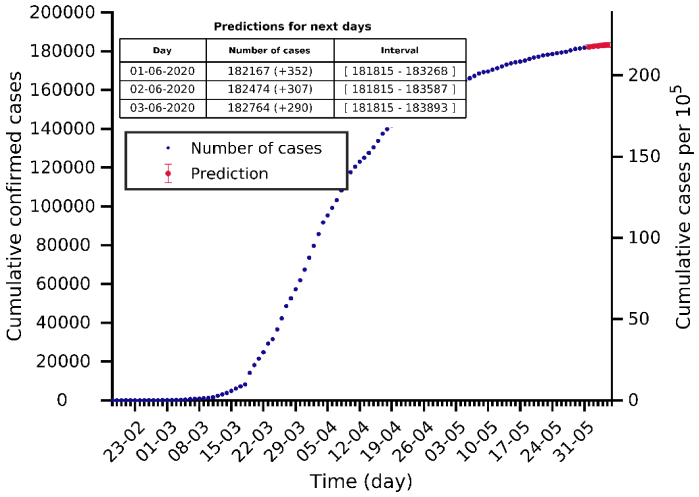


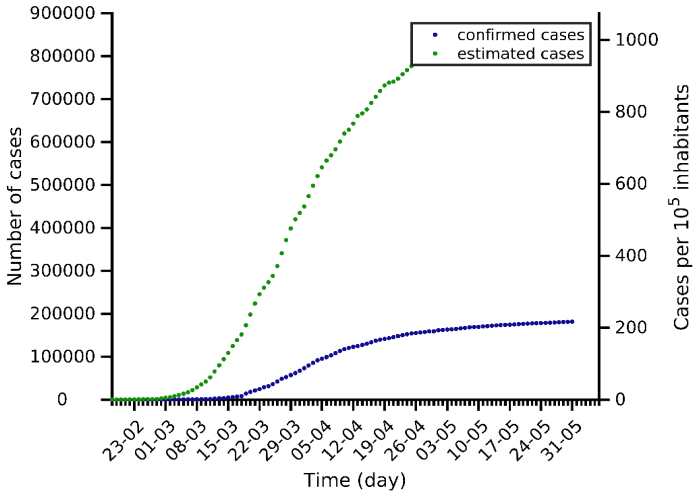


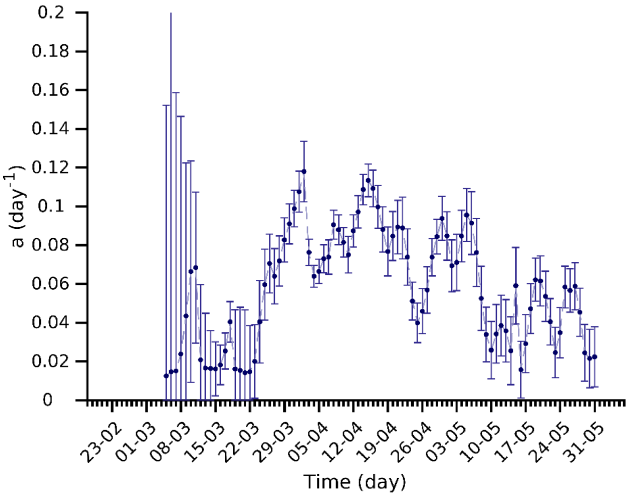


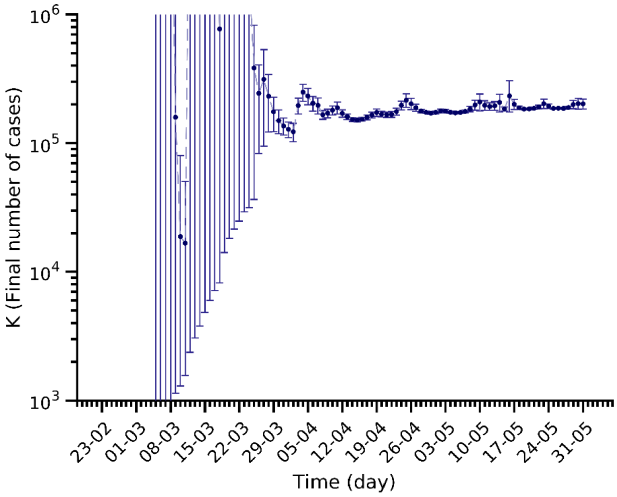


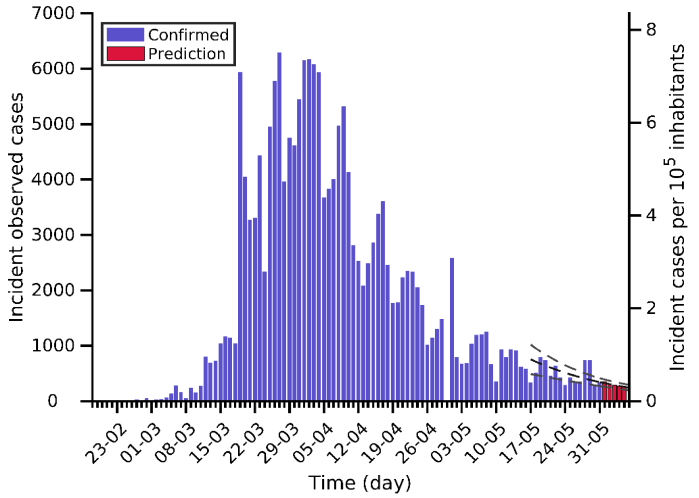
Germany 31-05-2020. Population: 83.8M. Current cumulated incidence: 217/10^5

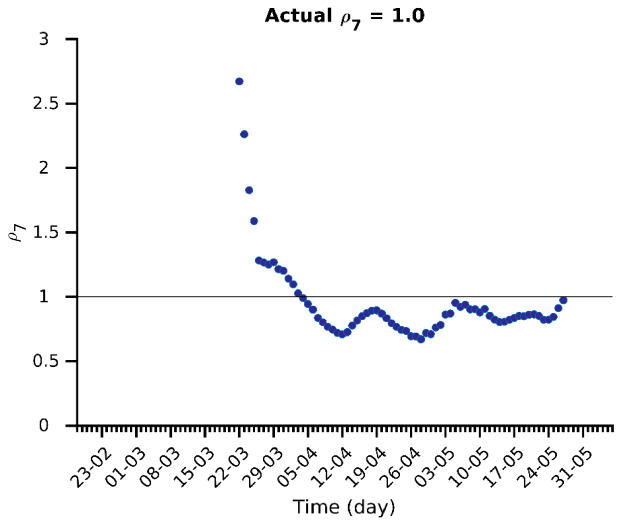


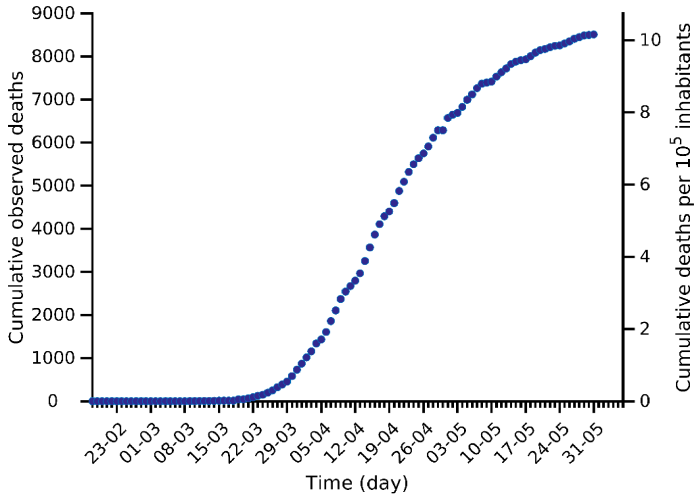


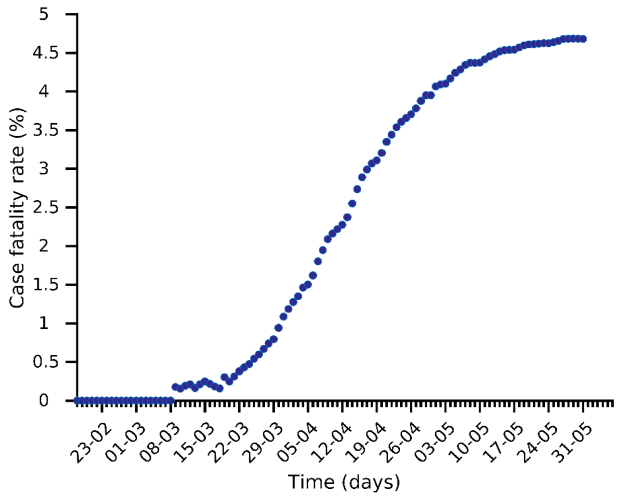




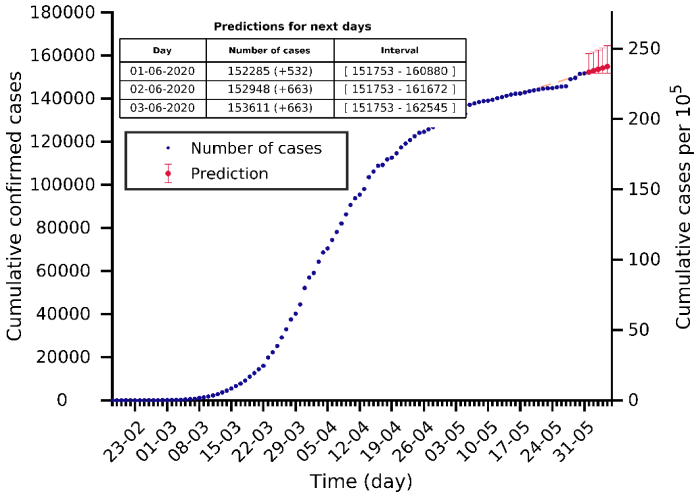


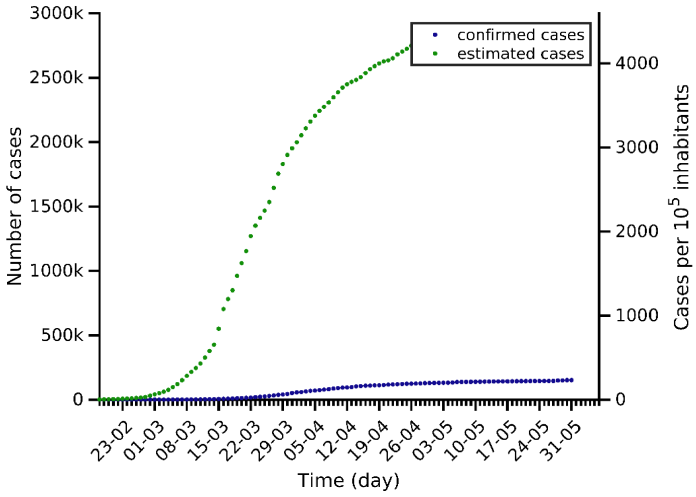


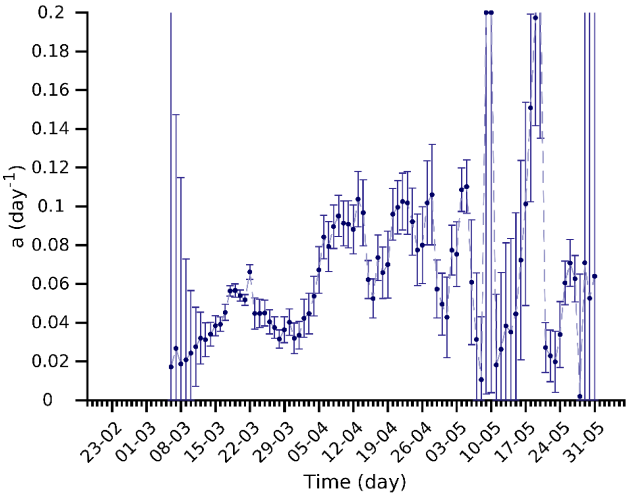


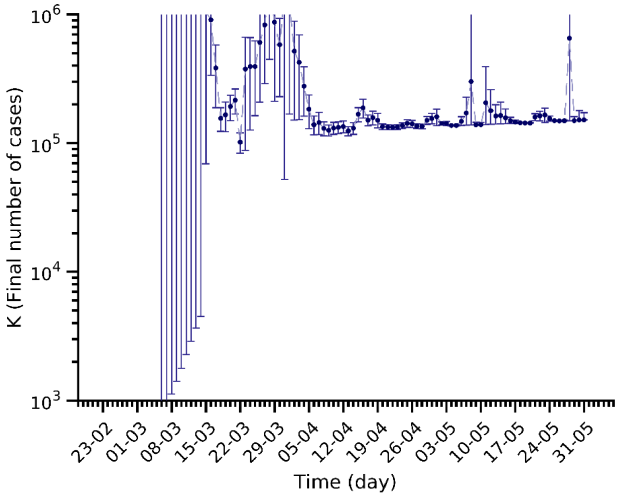


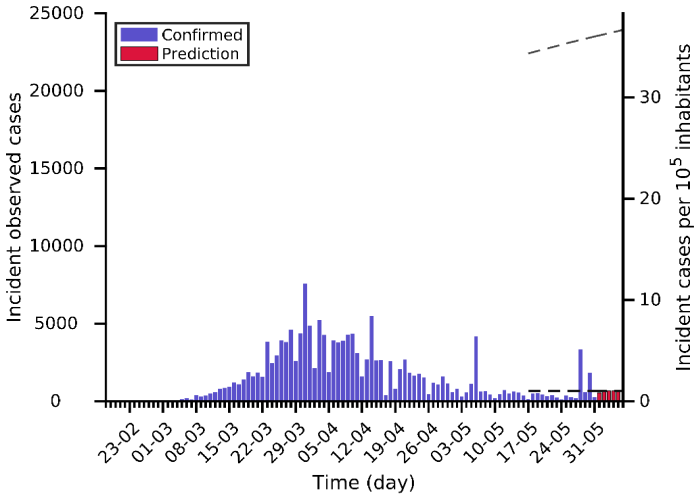
France 31-05-2020. Population: 65.3M. Current cumulated incidence: 232/10^5

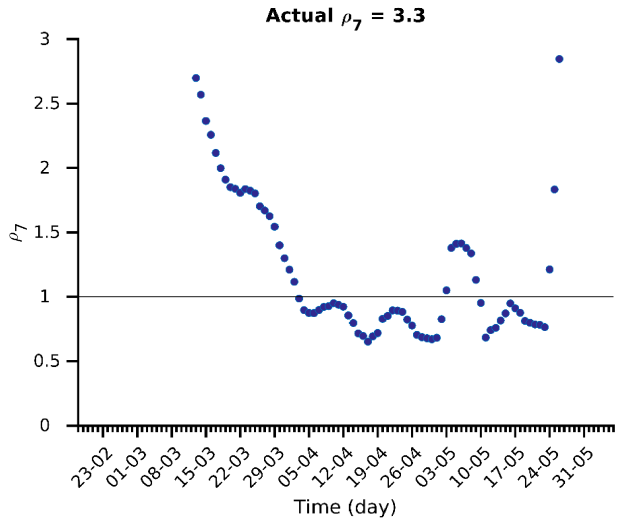


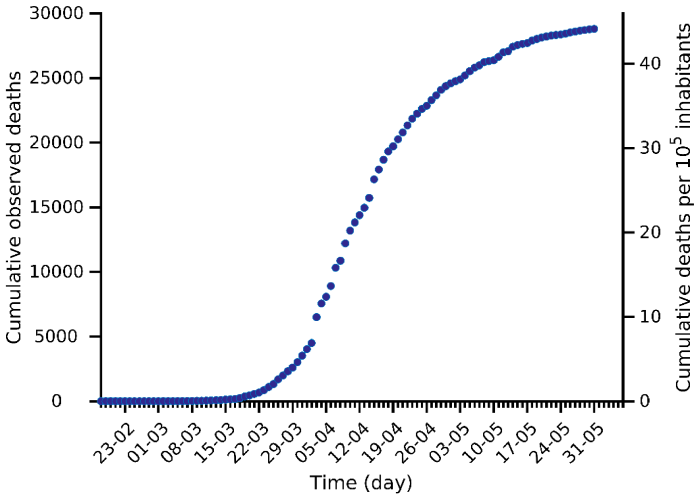


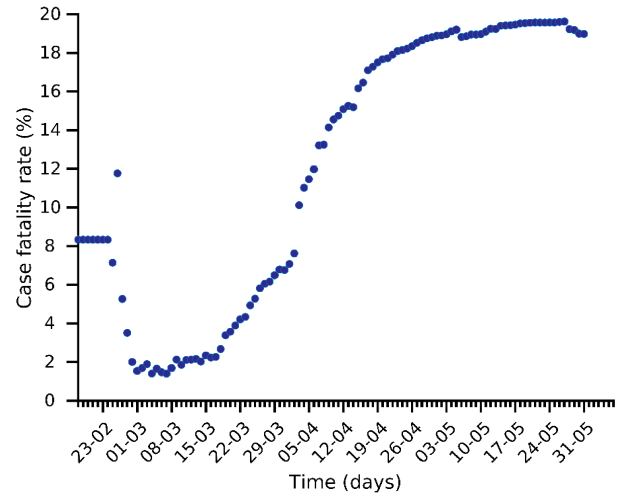




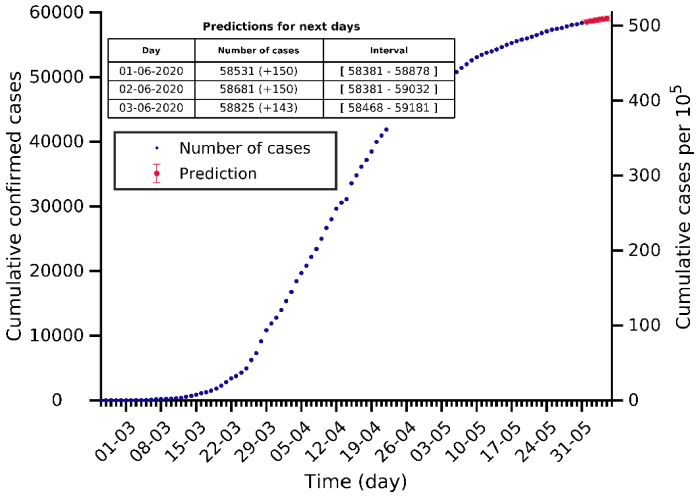


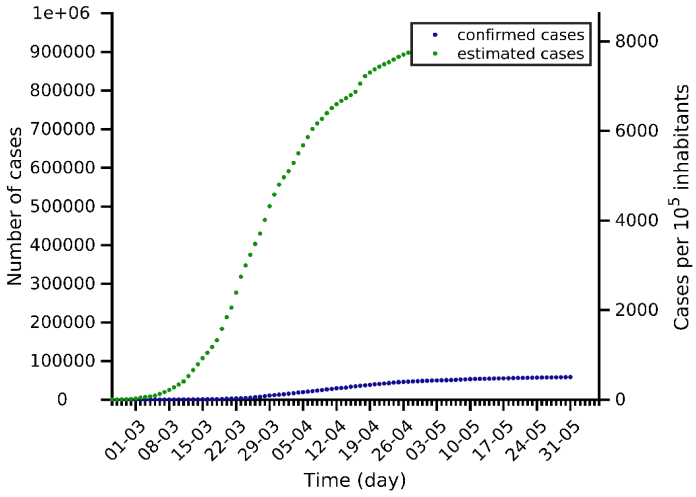


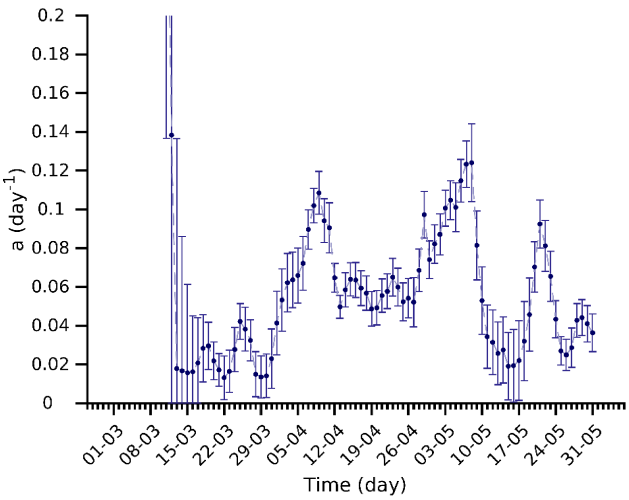


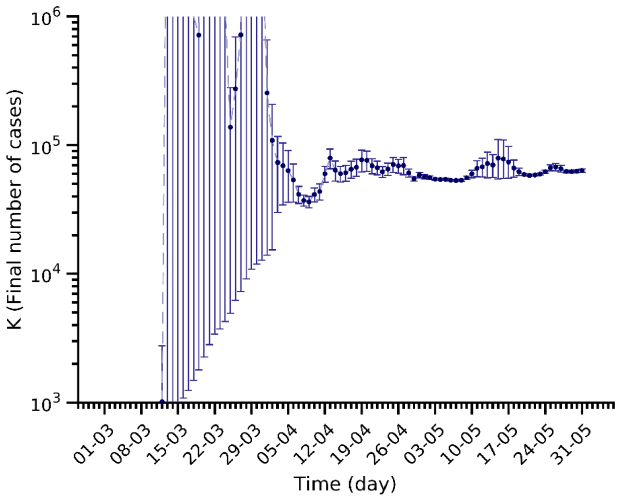


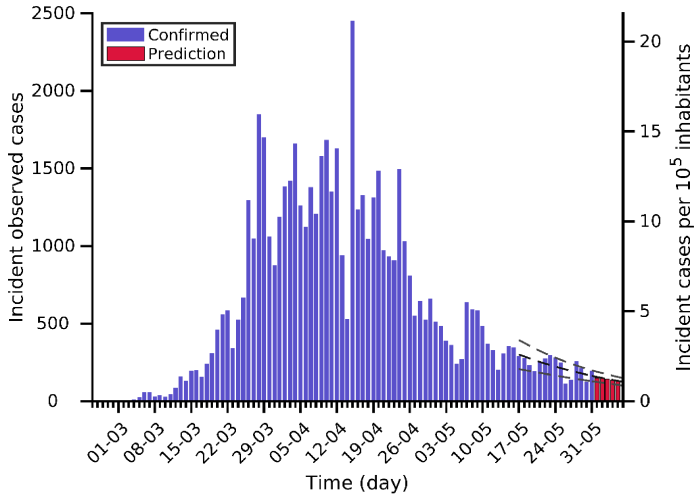
Belgium 31-05-2020. Population: 11.6M. Current cumulated incidence: 504/10^5

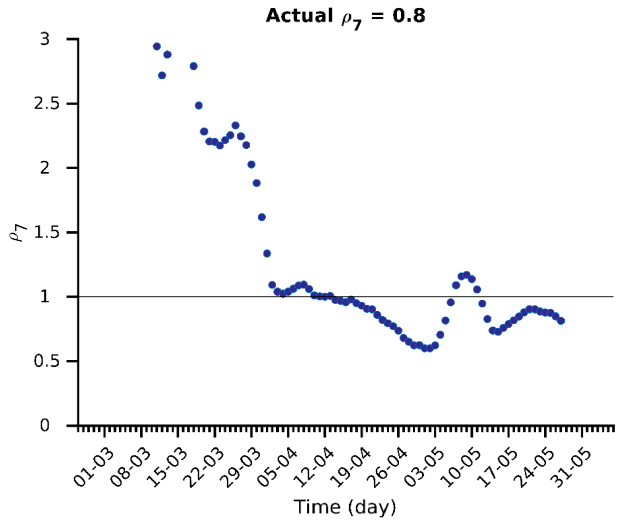


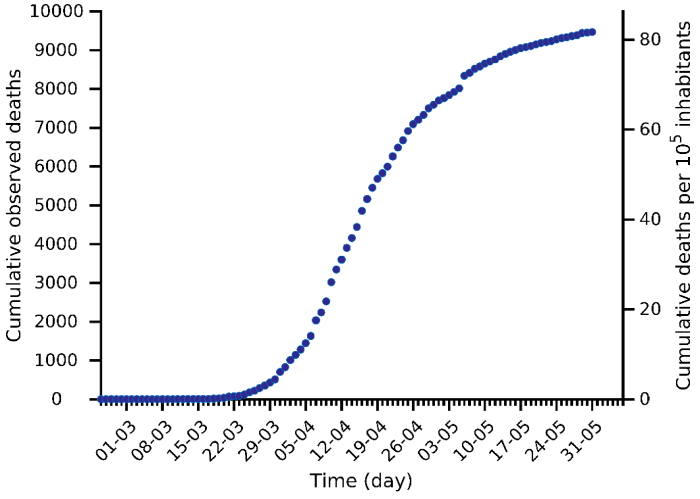


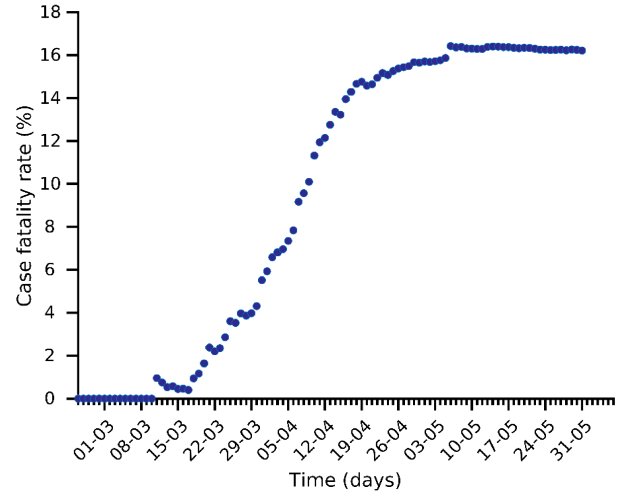




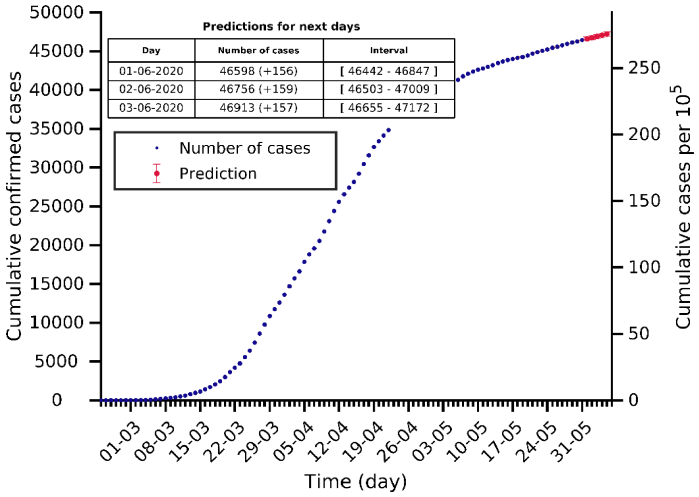


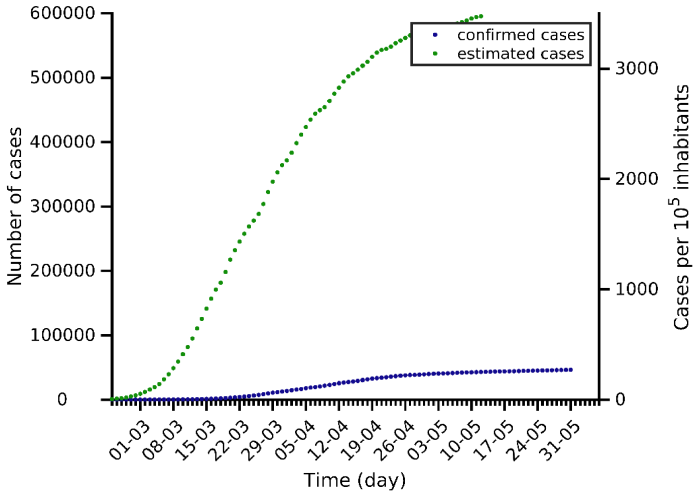


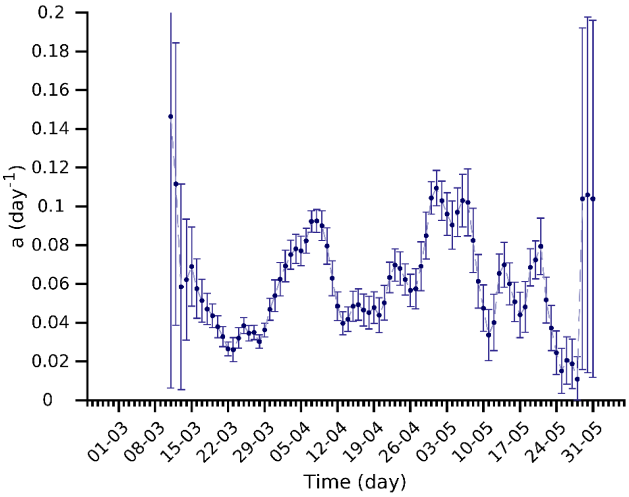


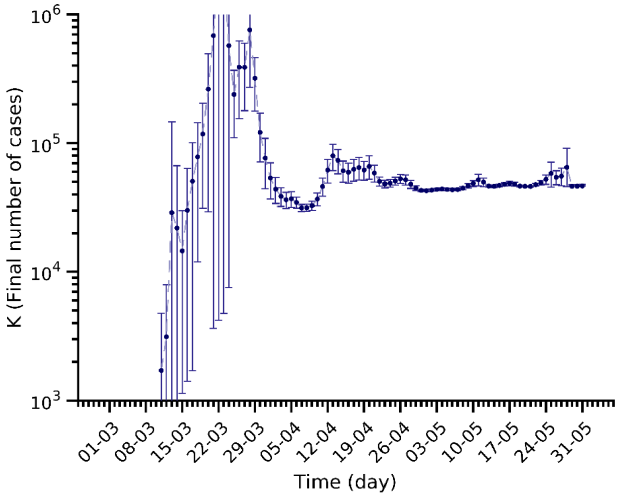


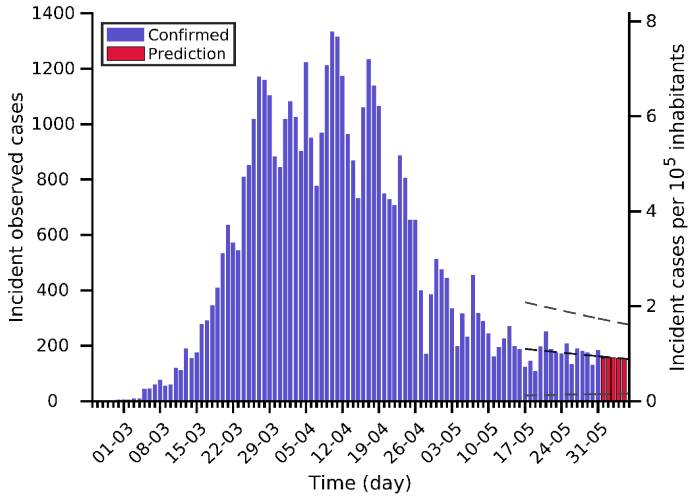
Netherlands 31-05-2020. Population: 17.1M. Current cumulated incidence: 271/10^5

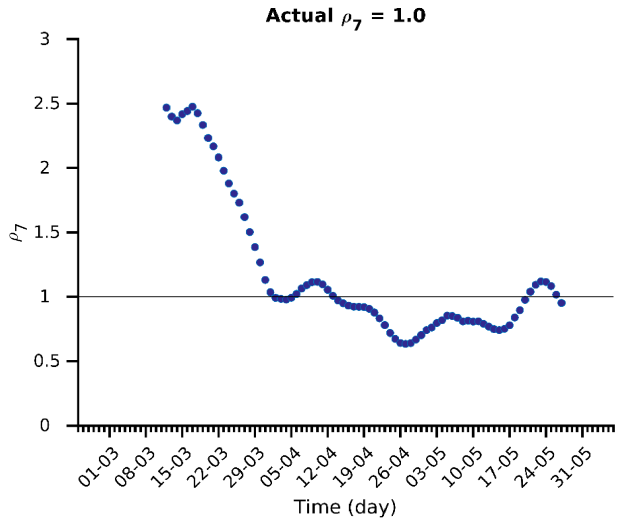


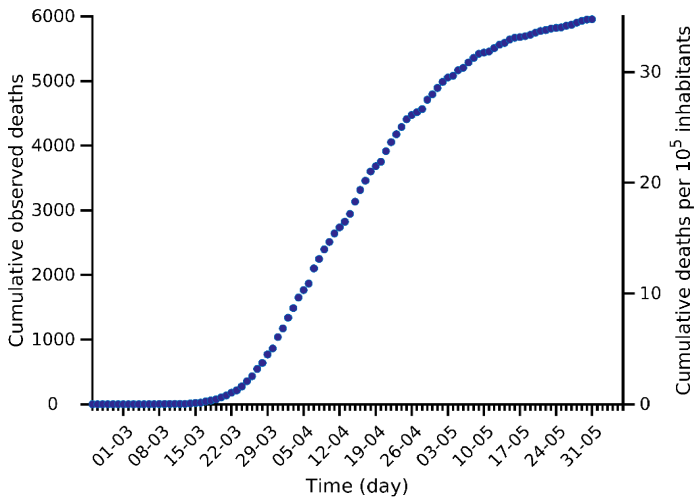


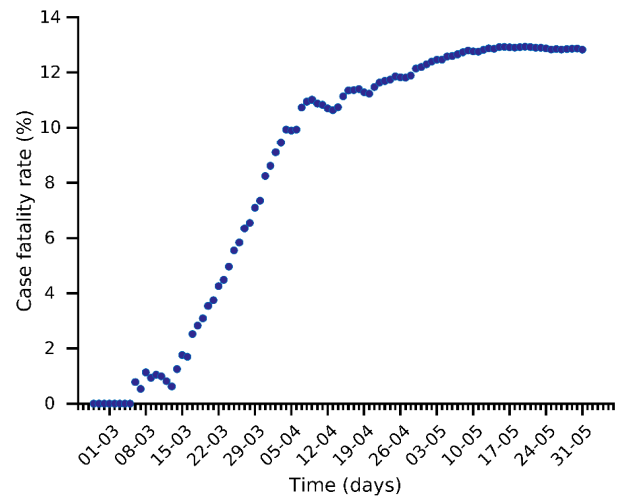




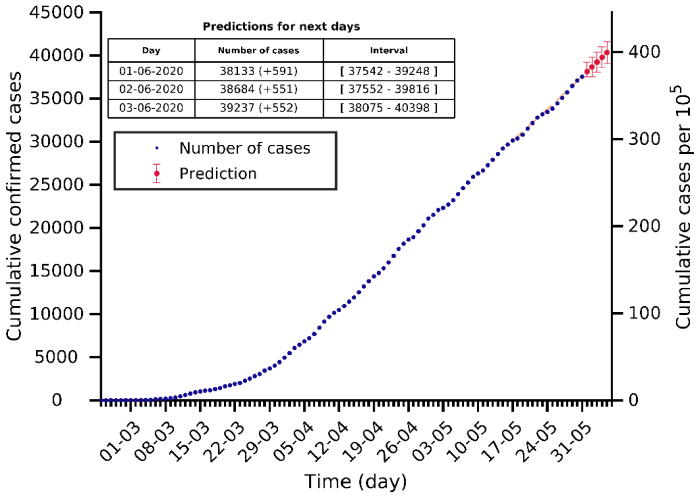


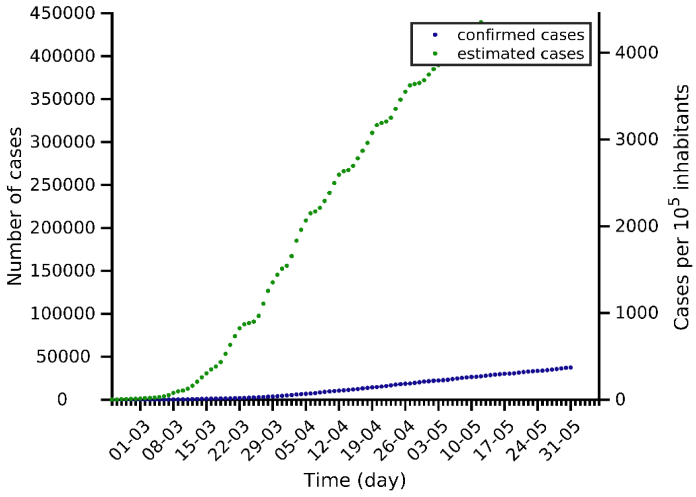


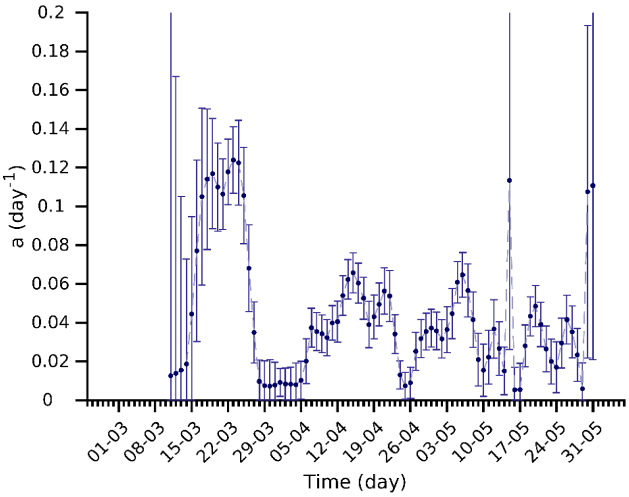


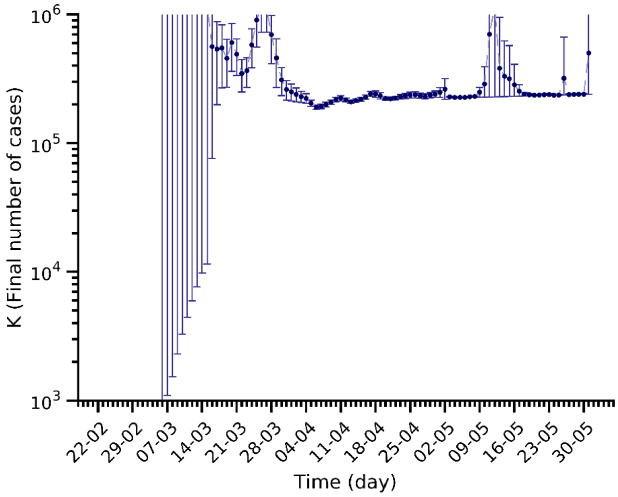


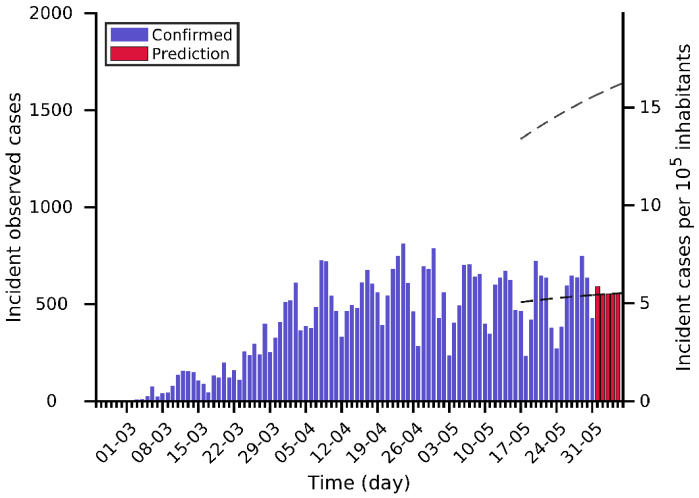
Sweden 31-05-2020. Population: 10.1M. Current cumulated incidence: 372/10^5

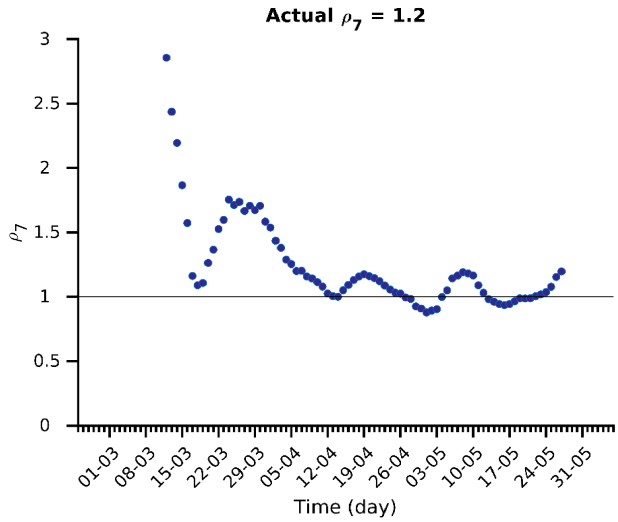


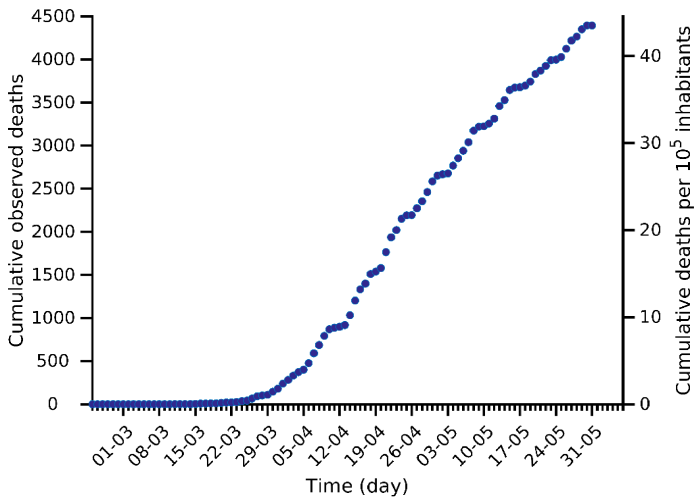


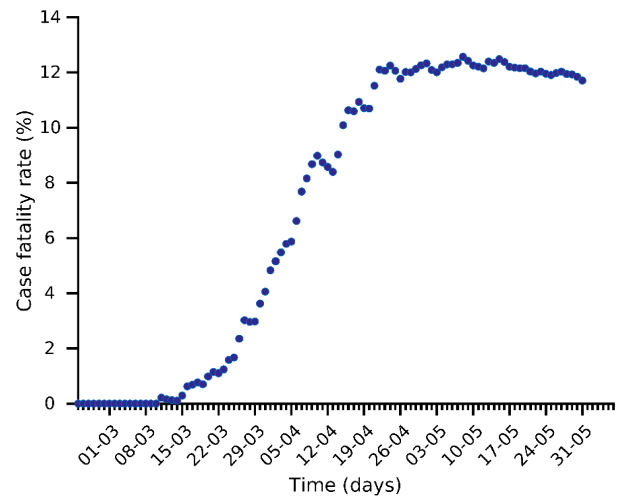




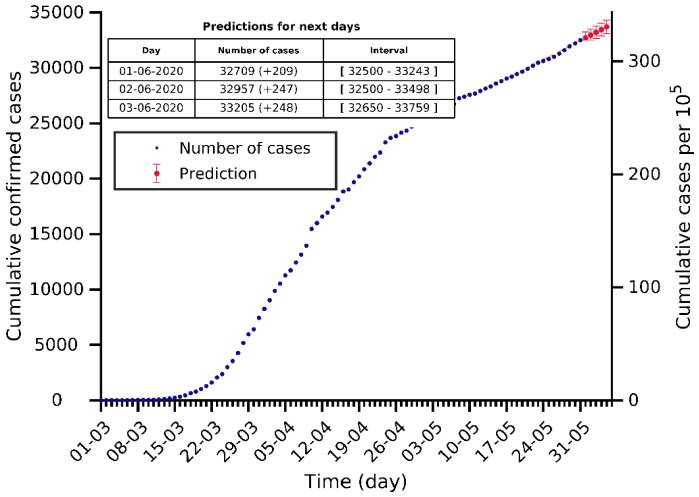


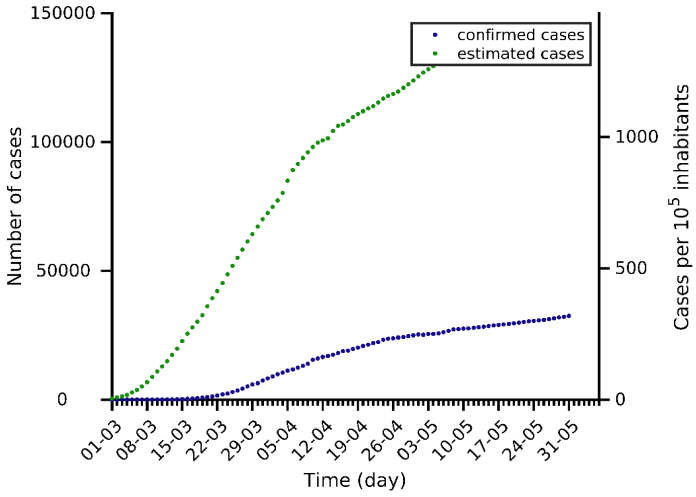


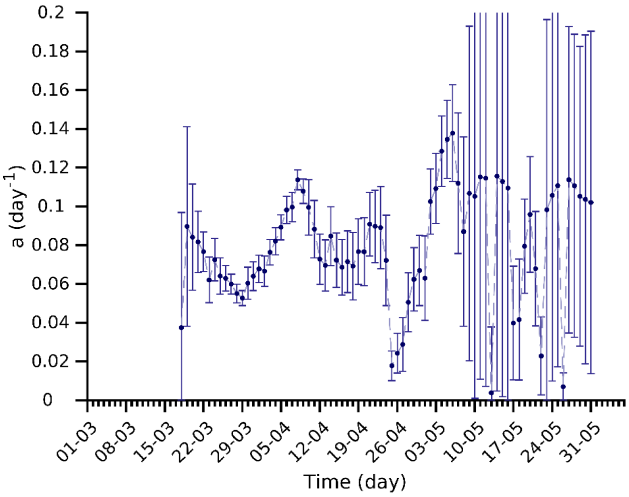


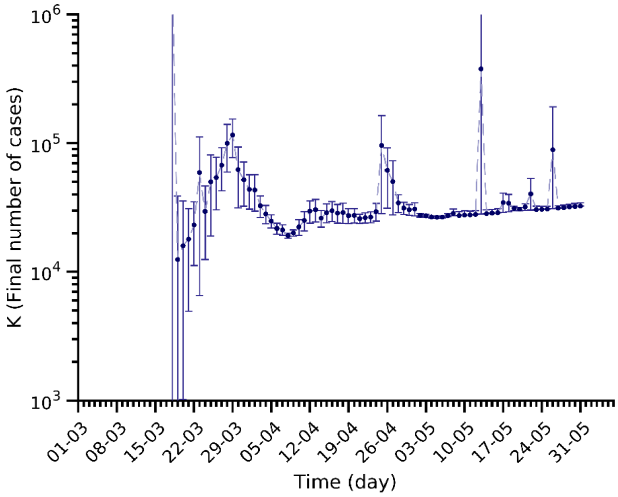


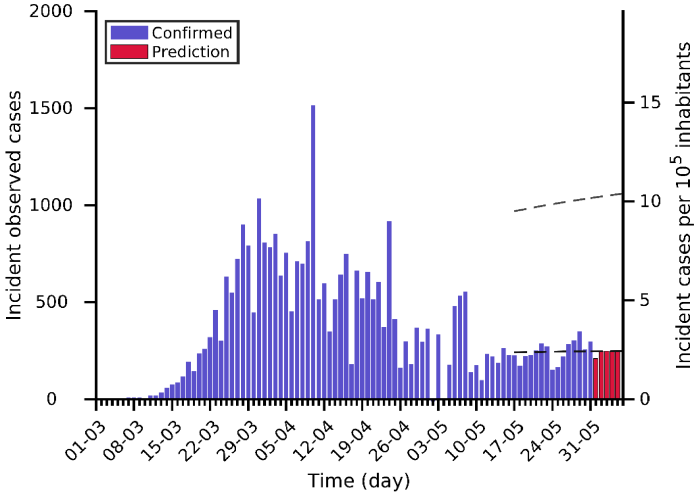
Portugal 31-05-2020. Population: 10.2M. Current cumulated incidence: 319/10⁵

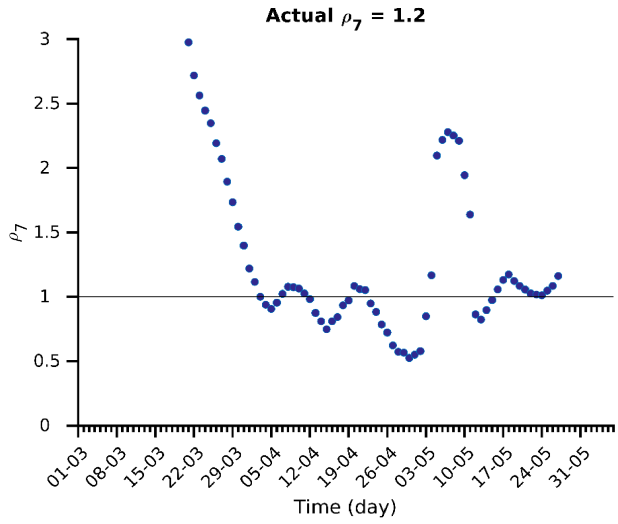


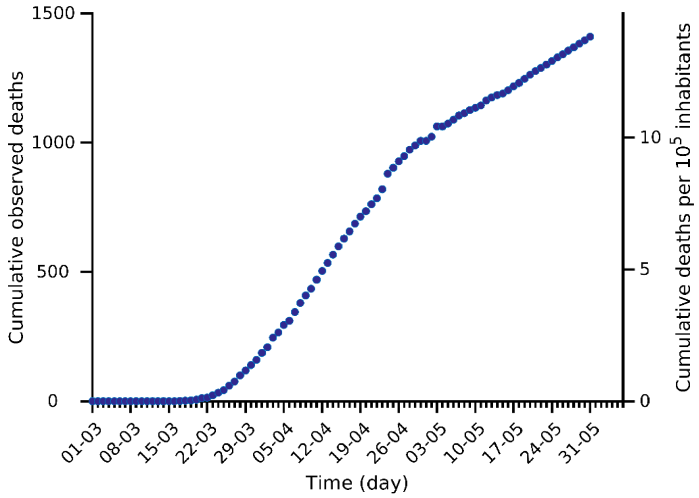


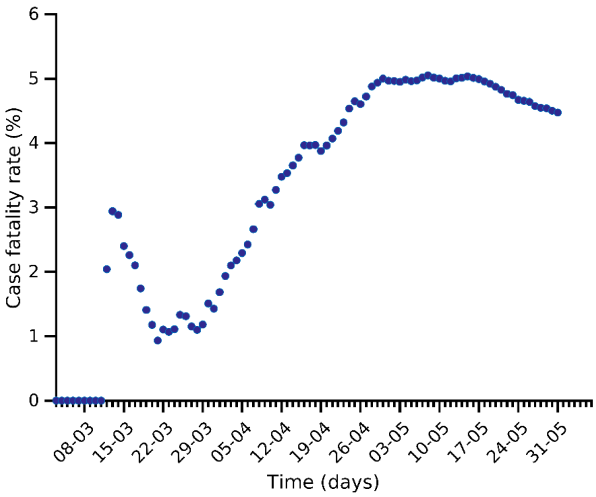




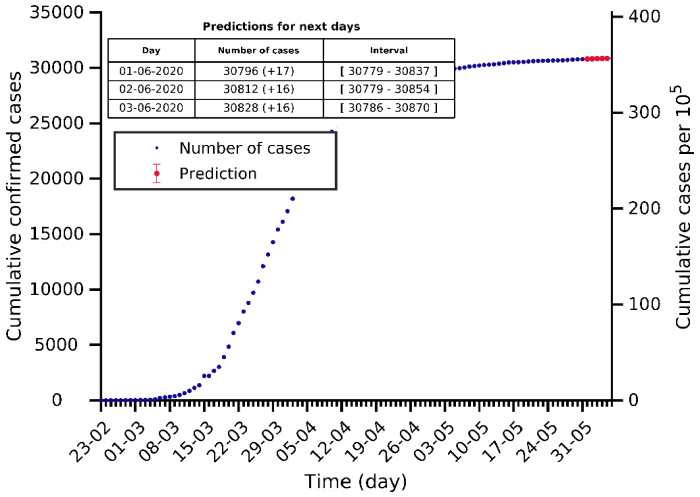


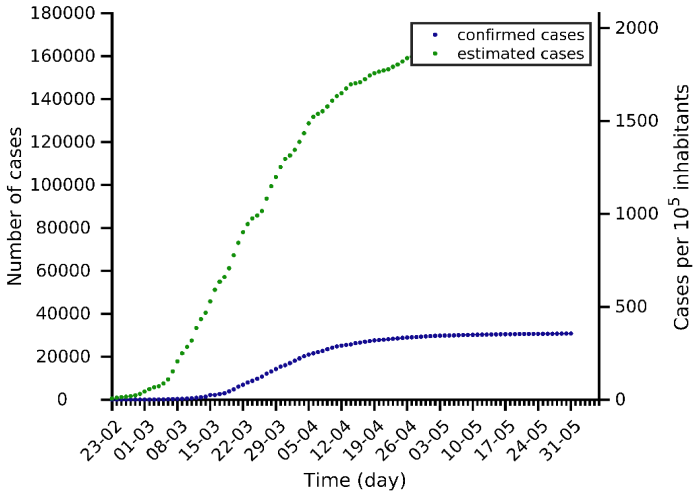


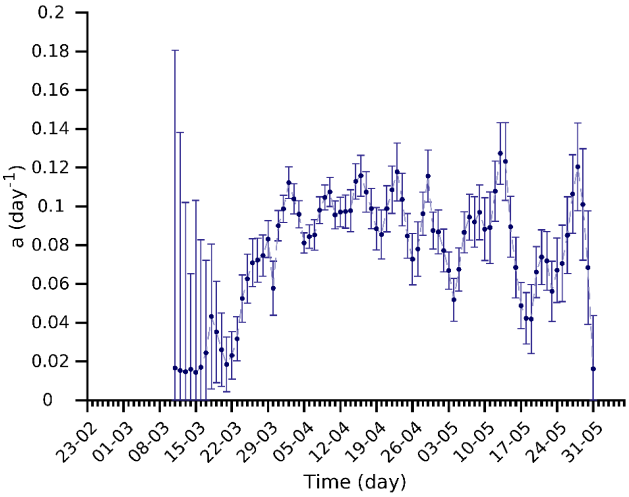


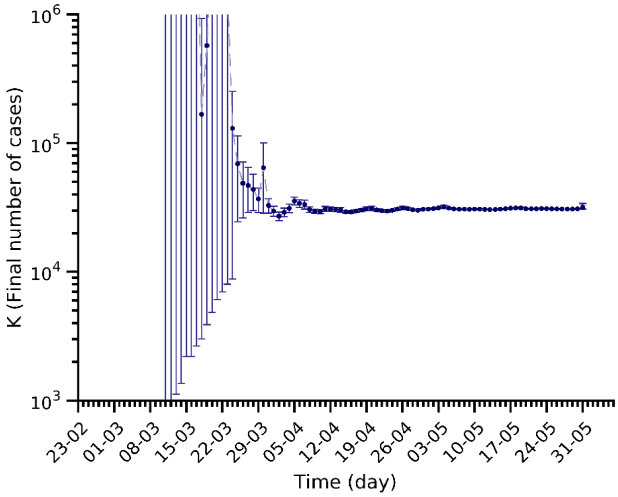


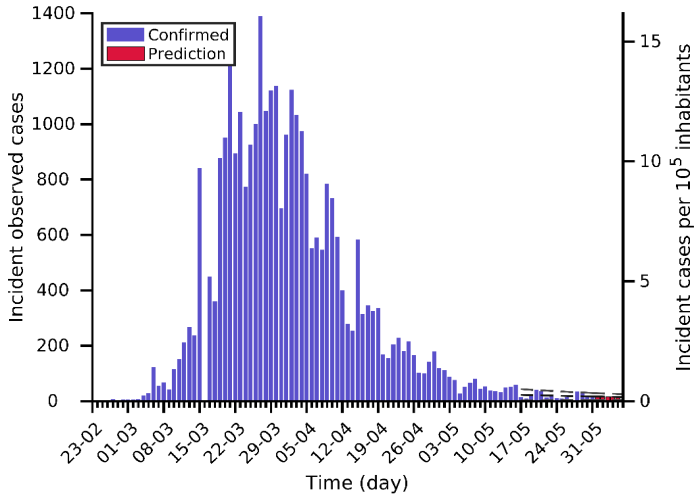
Switzerland 31-05-2020. Population: 8.7M. Current cumulated incidence: 356/10^5

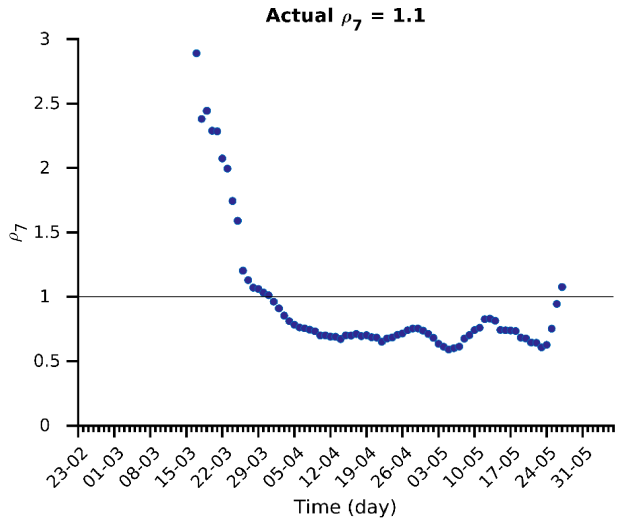


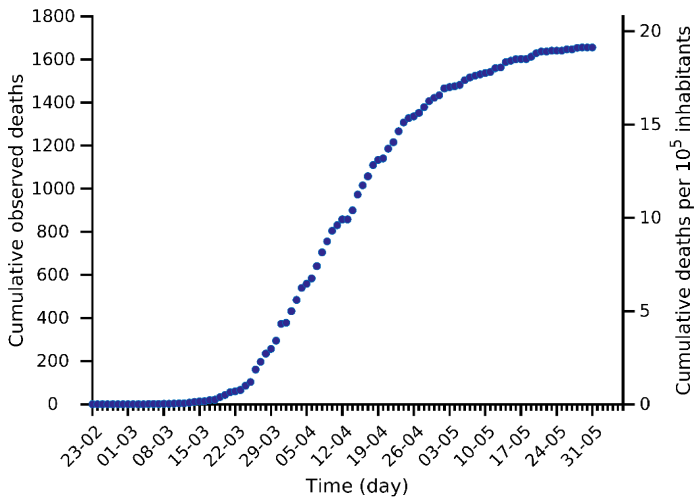


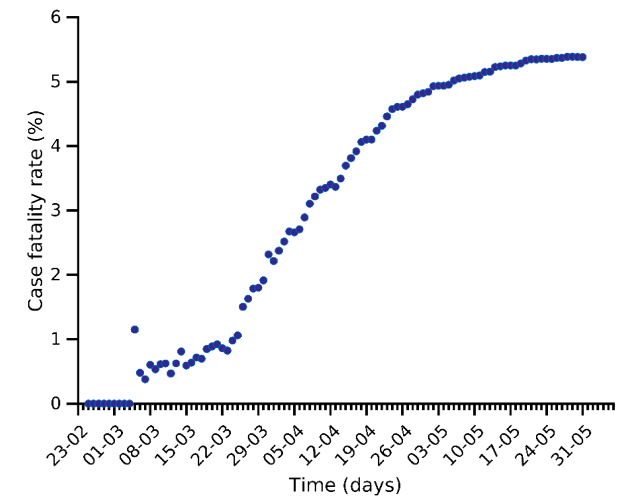




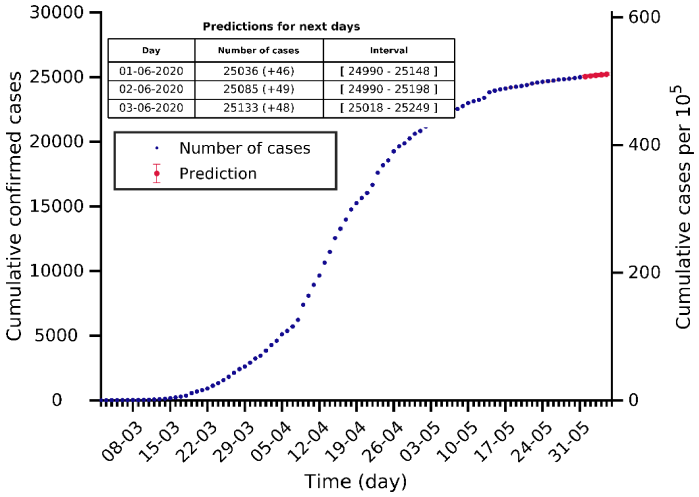


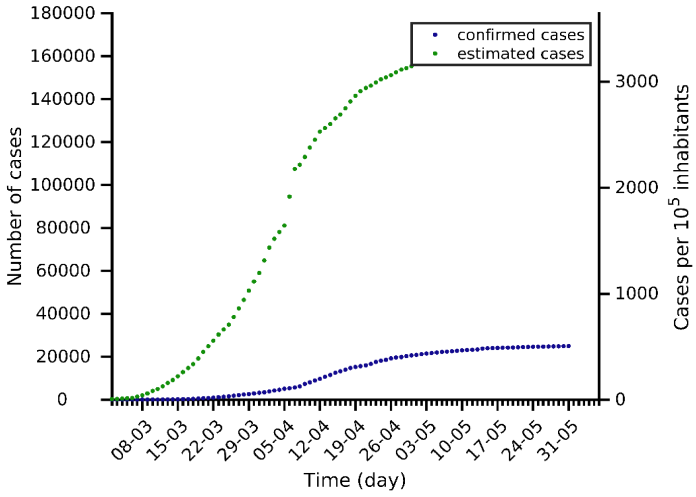


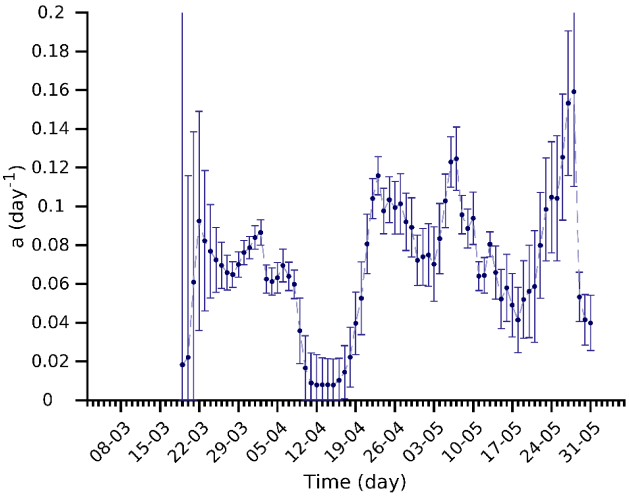


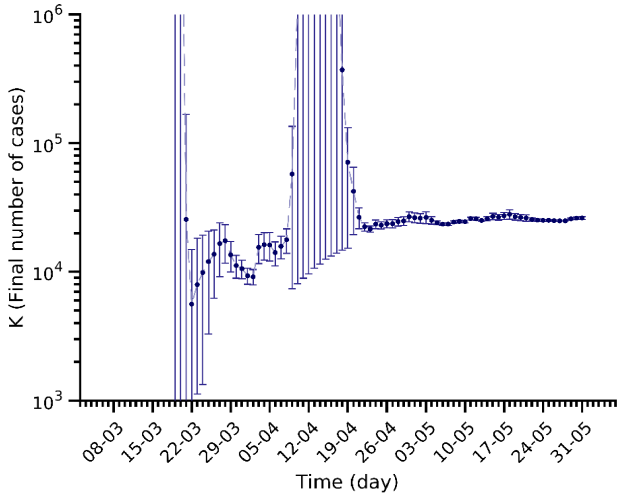


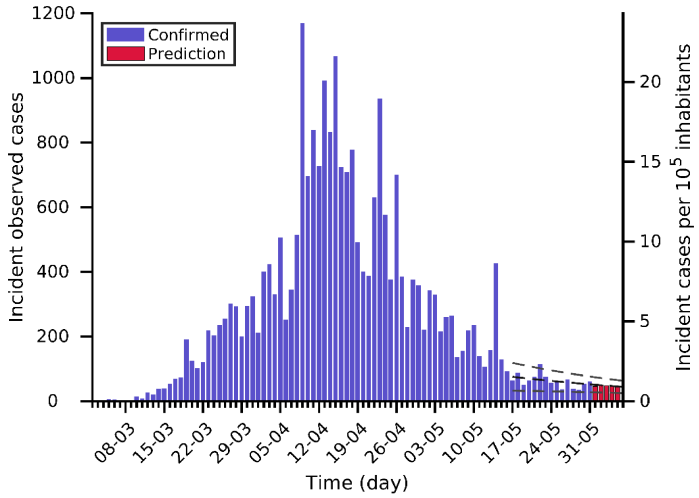
Ireland 31-05-2020. Population: 4.9M. Current cumulated incidence: 506/10⁵

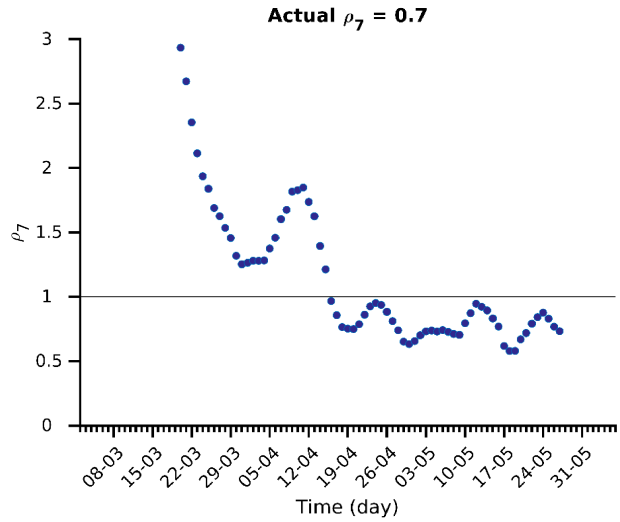


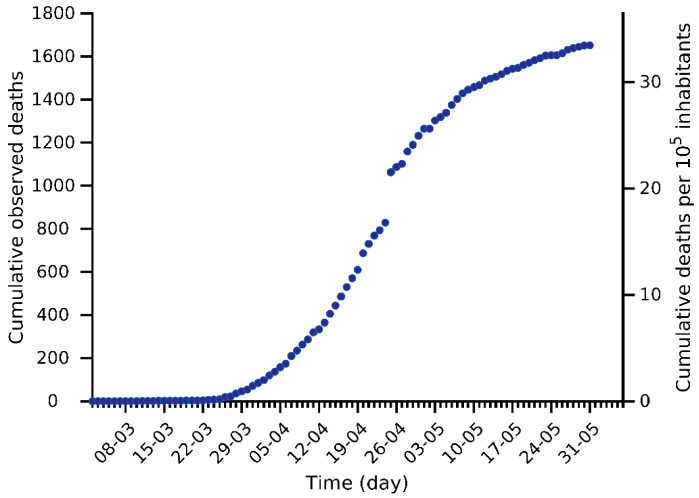


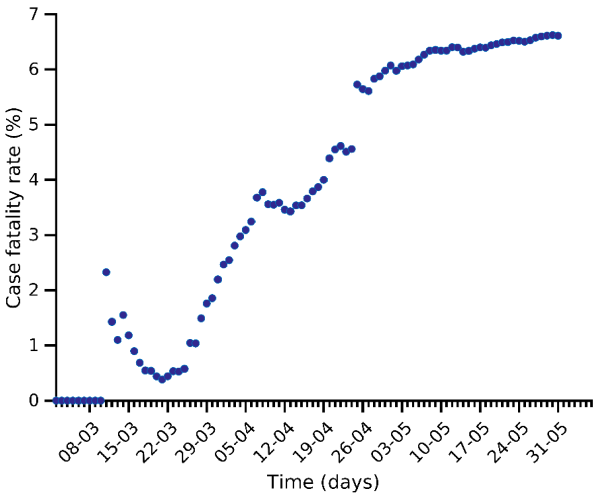




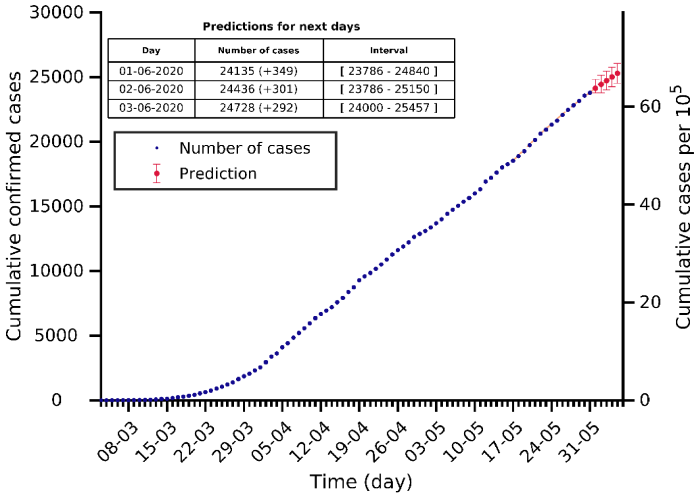


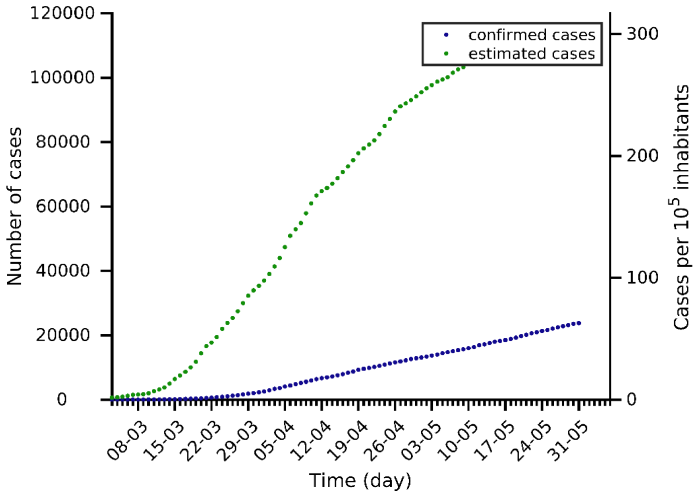


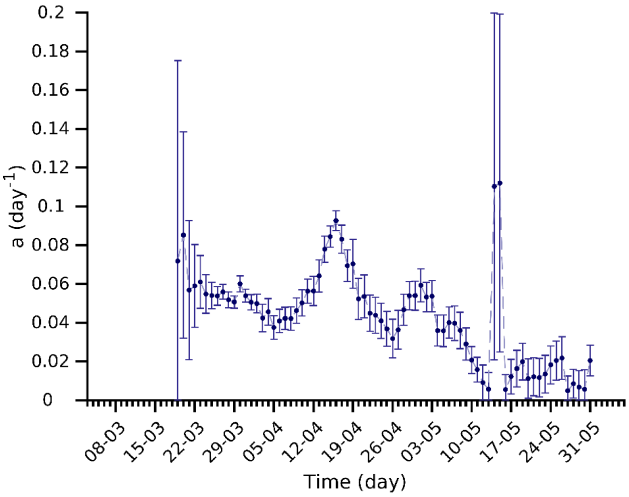


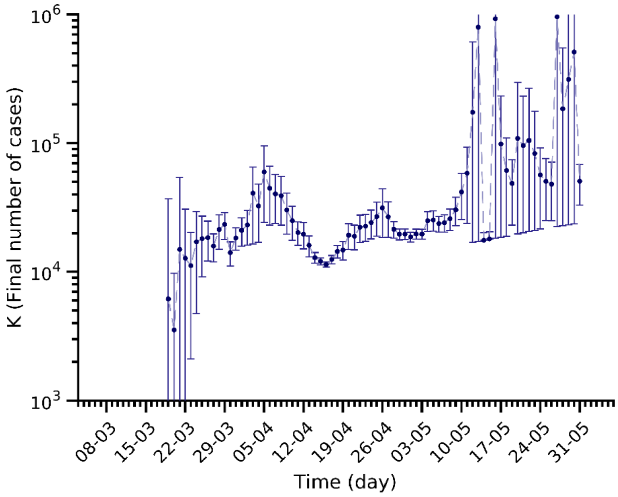


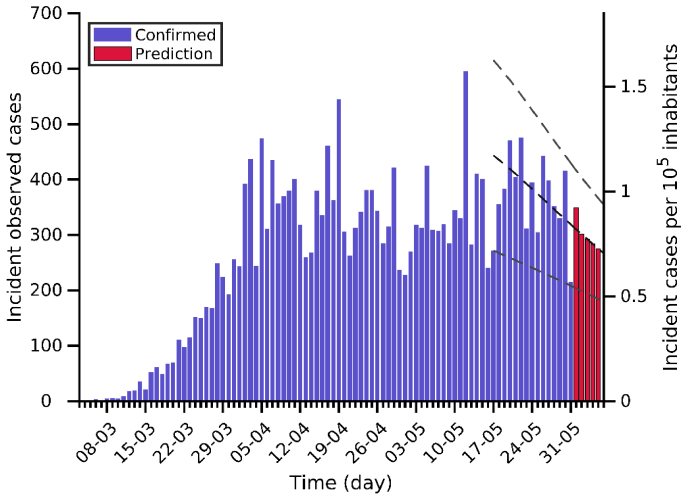
Poland 31-05-2020. Population: 37.8M. Current cumulated incidence: 63/10^5

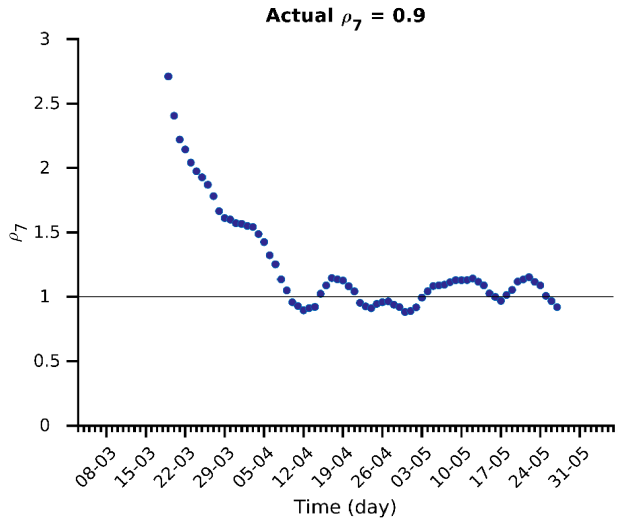


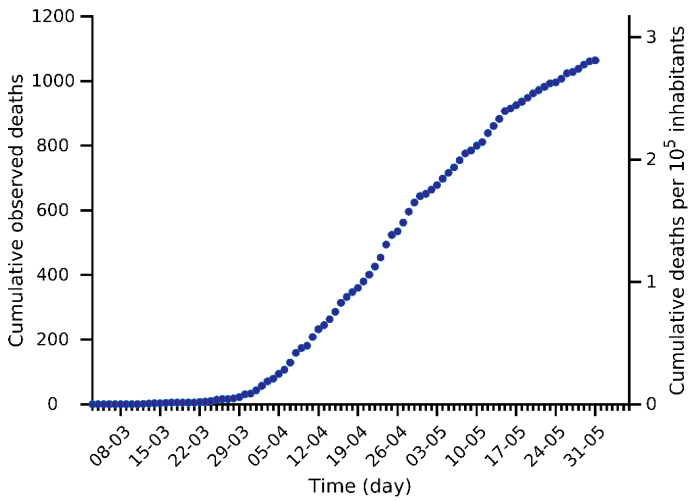


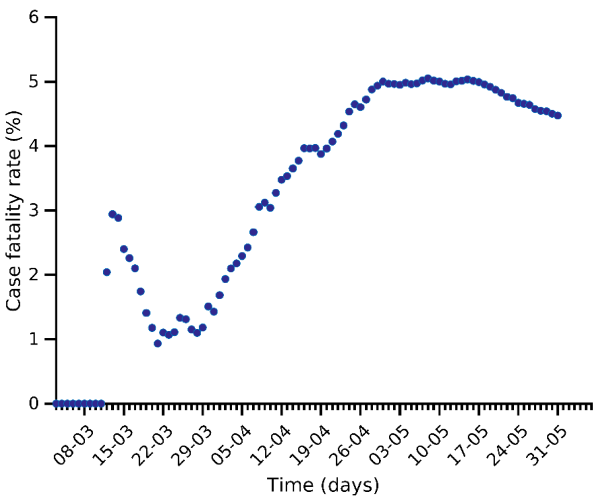




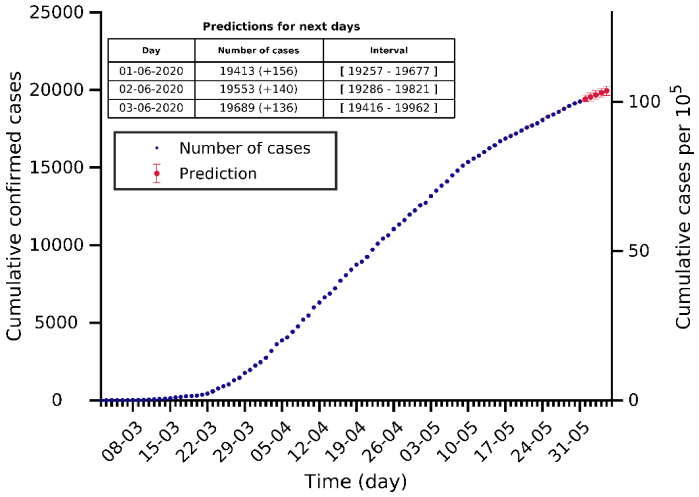


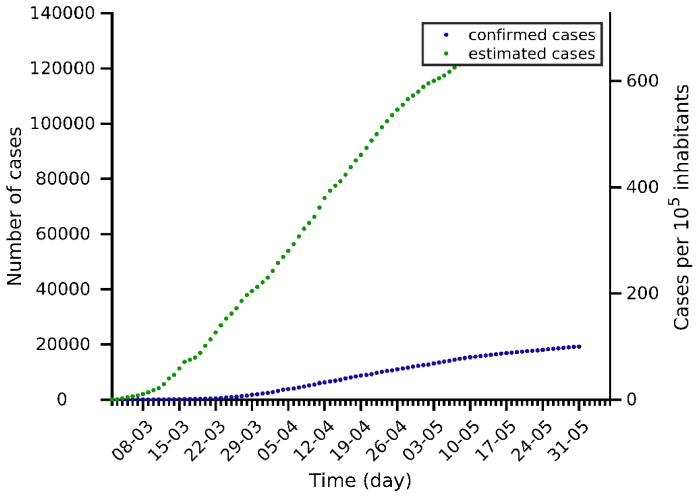


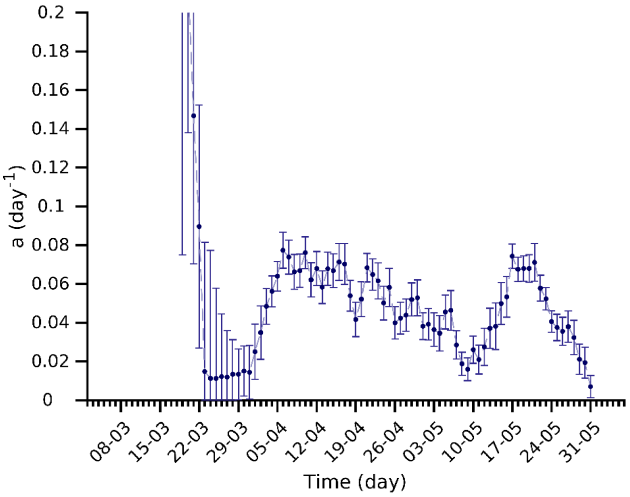


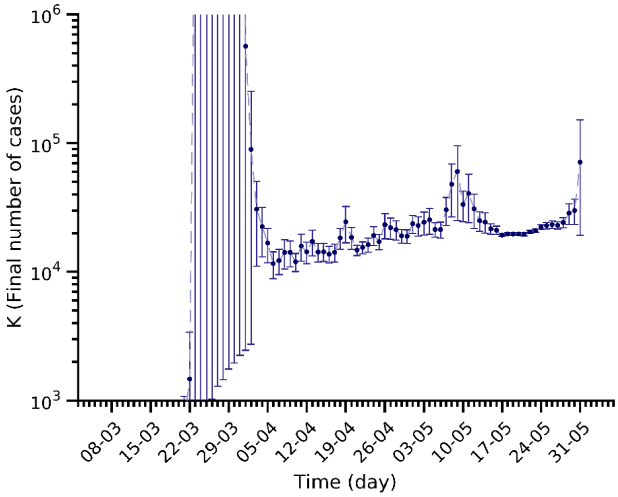


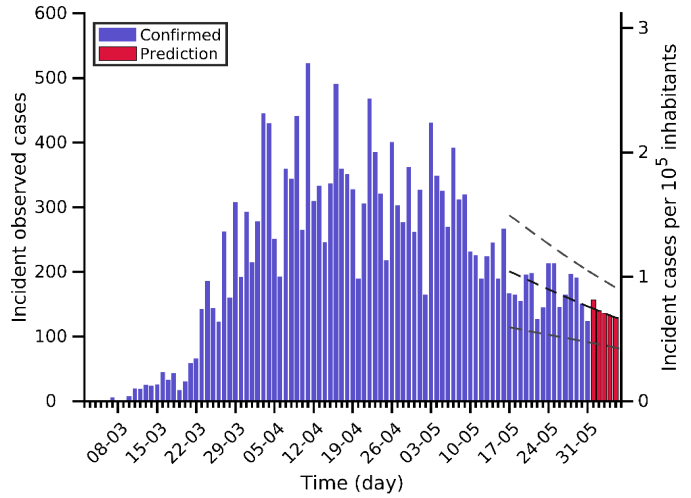
Romania 31-05-2020. Population: 19.2M. Current cumulated incidence: 100/10⁵

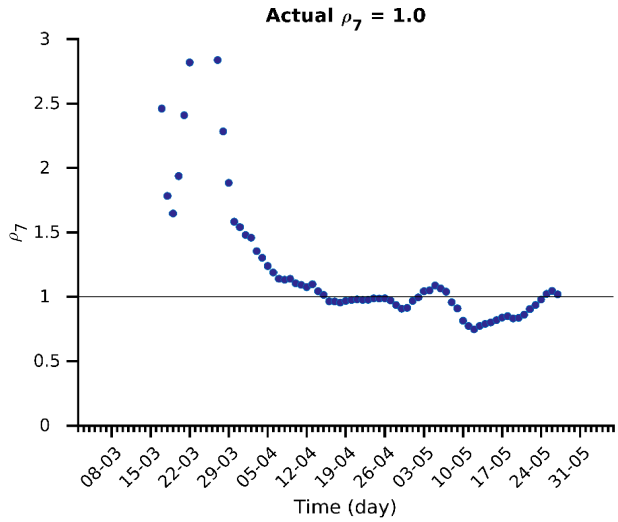


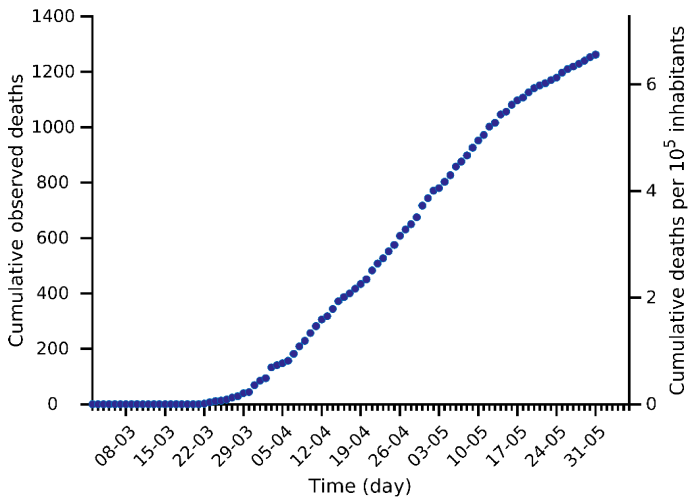


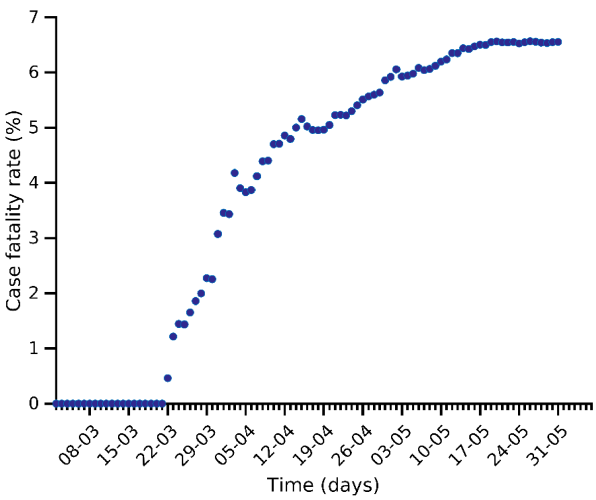




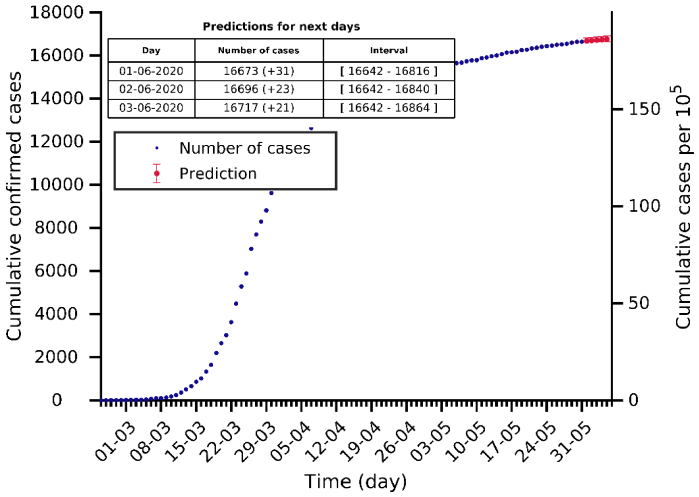


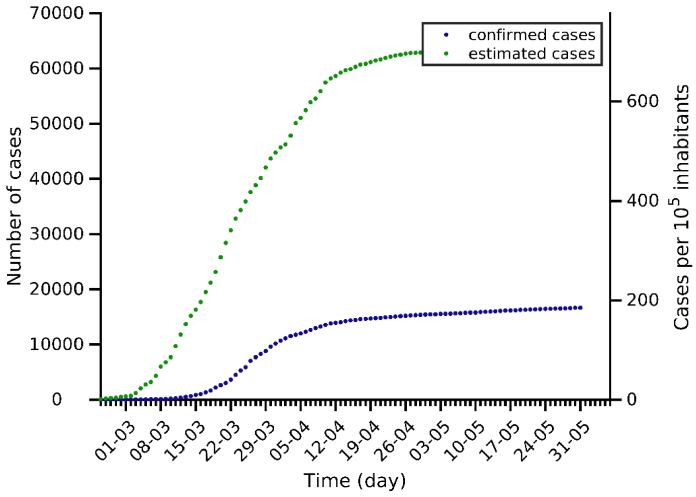


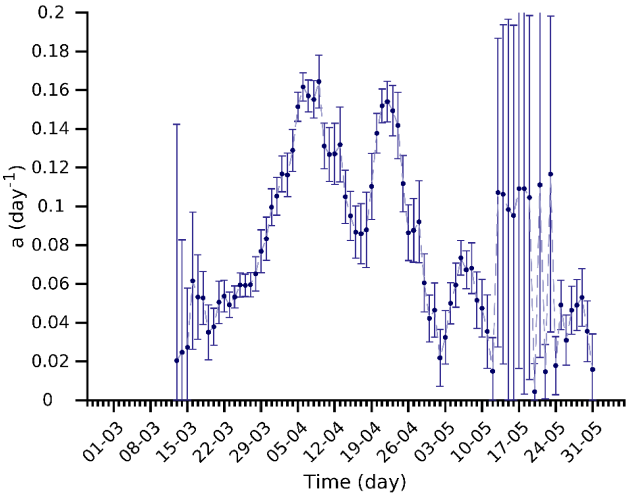


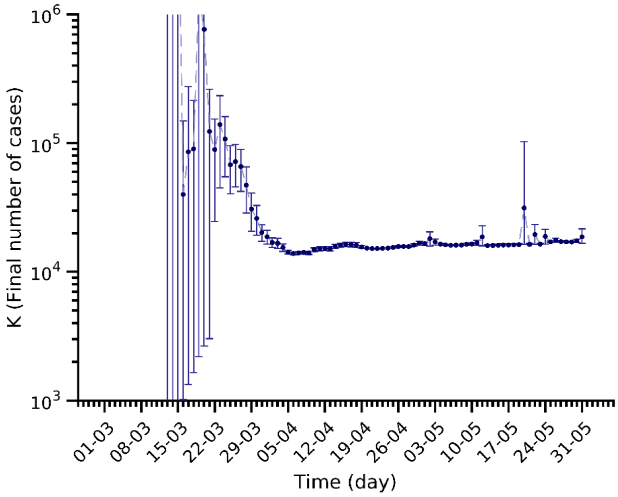


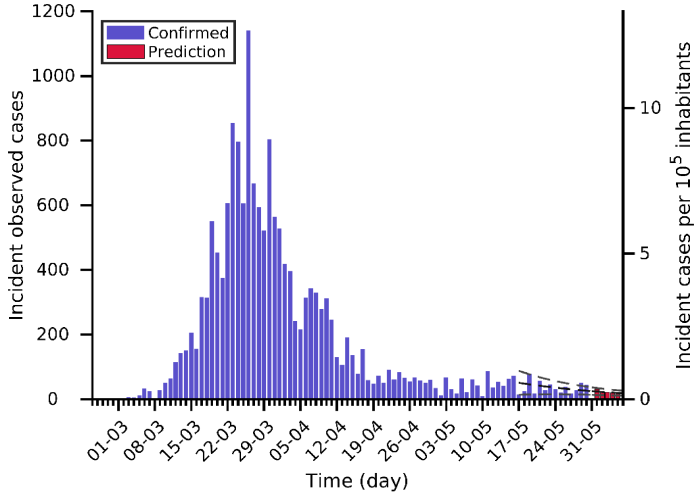
Austria 31-05-2020. Population: 9.0M. Current cumulated incidence: 185/10^5

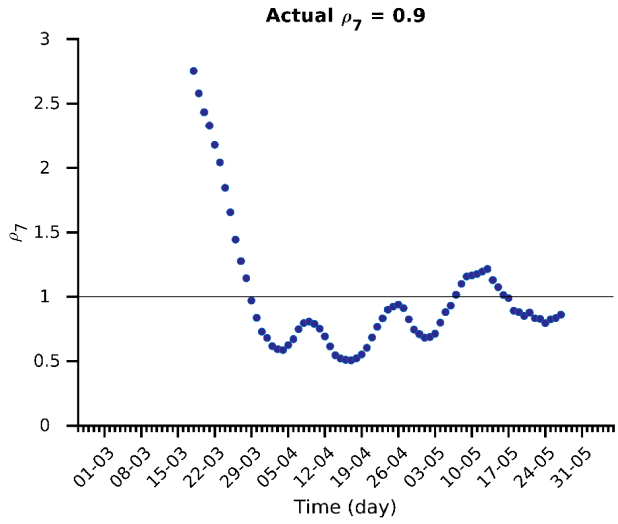


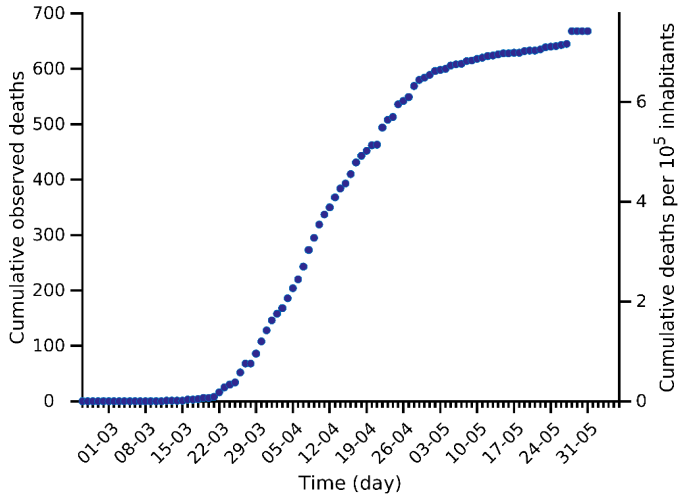


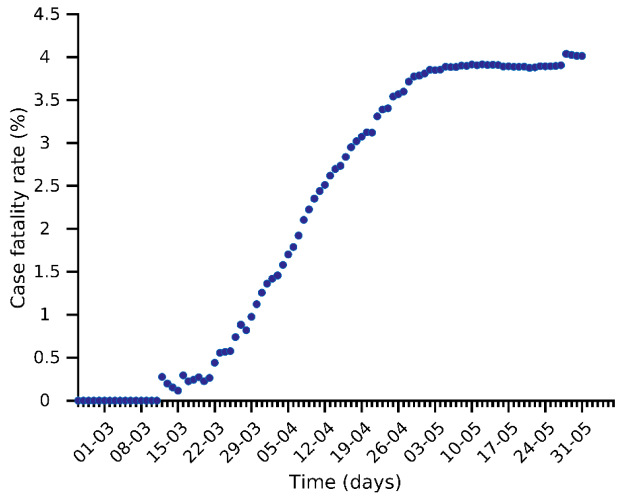




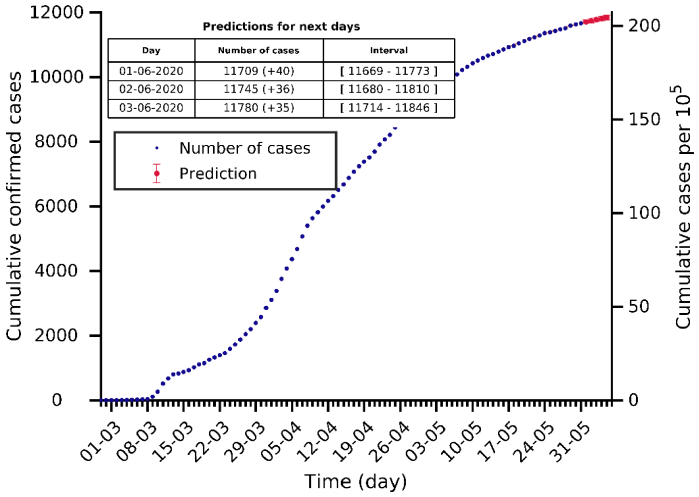


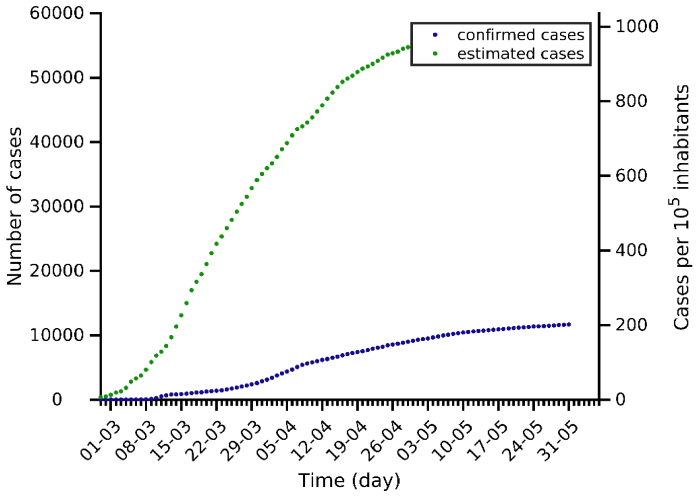


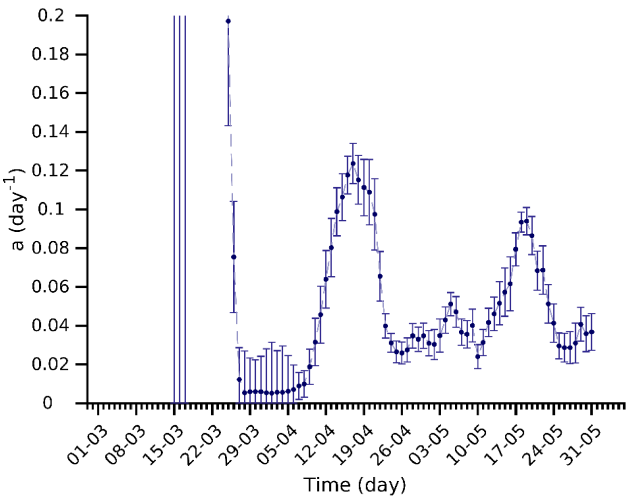


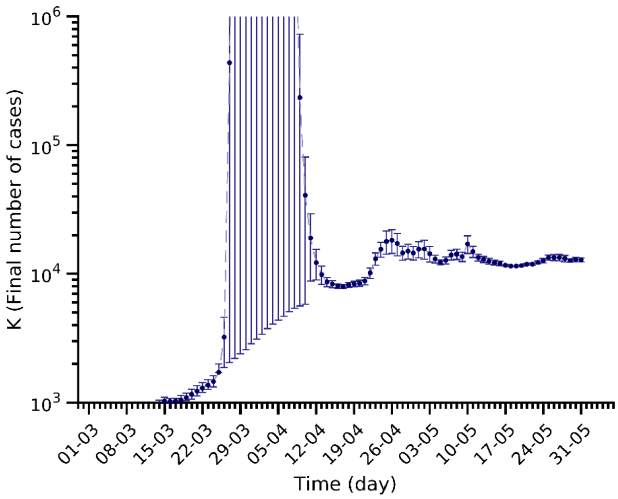


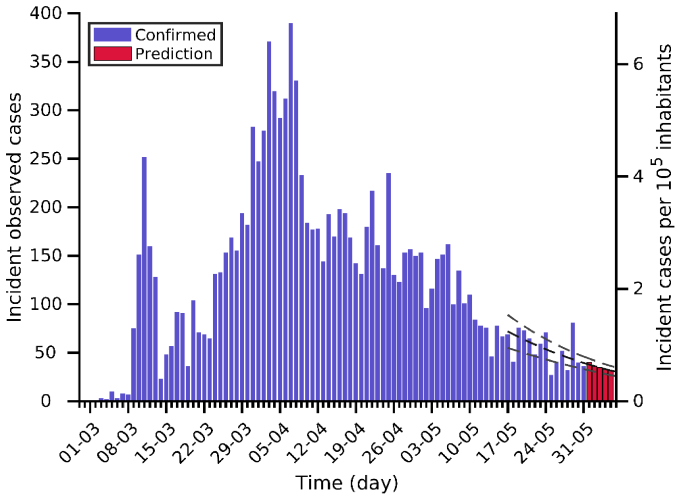
Denmark 31-05-2020. Population: 5.8M. Current cumulated incidence: 201/10⁵

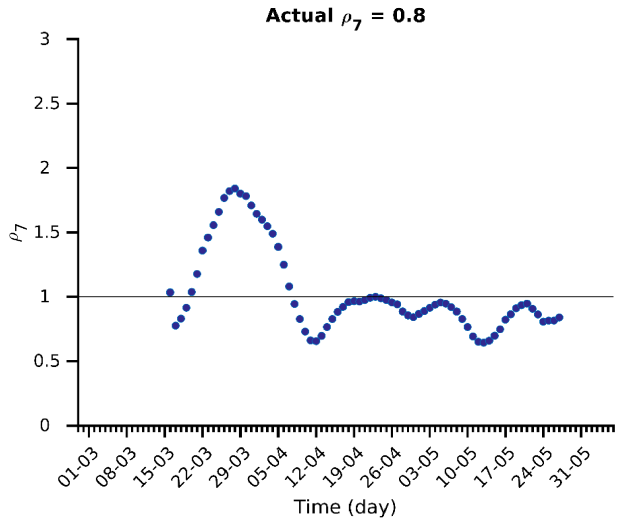


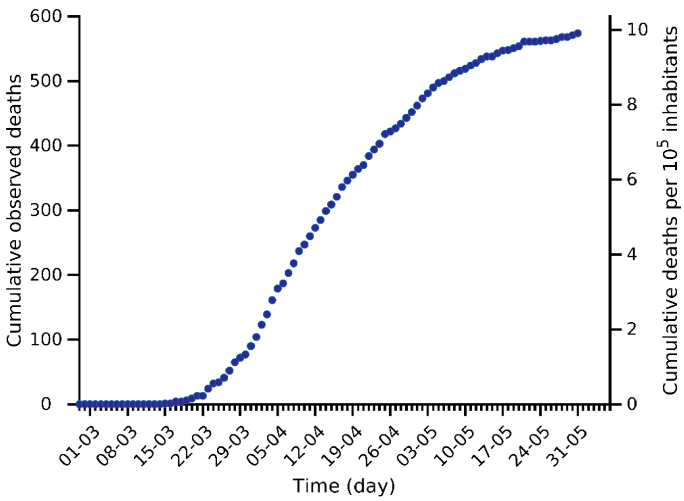


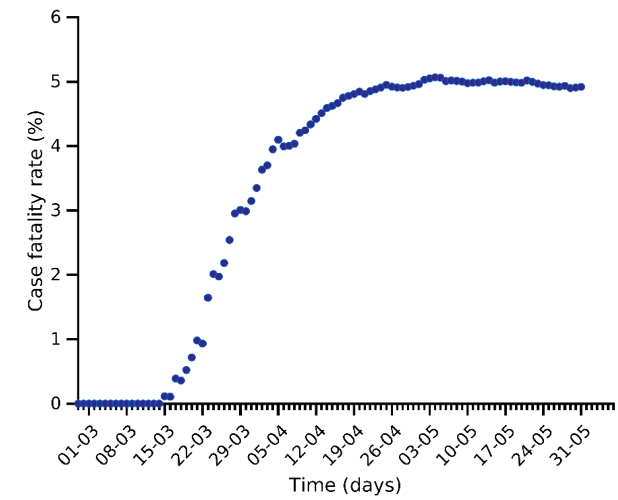




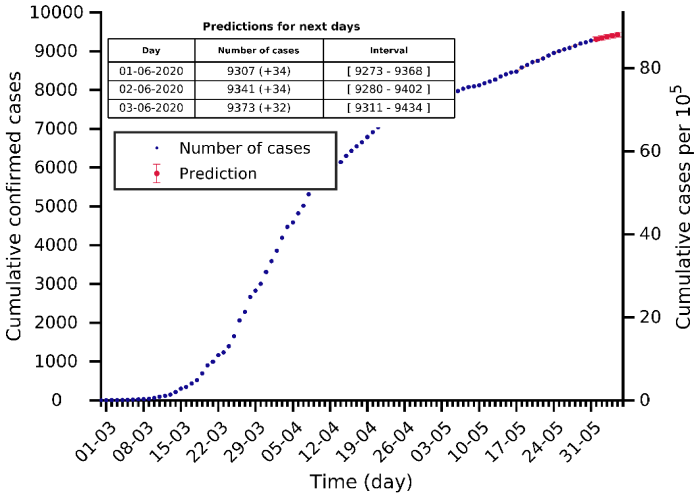


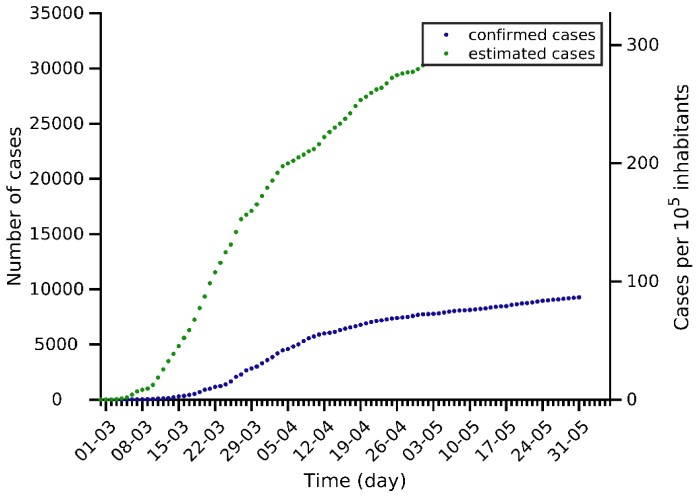


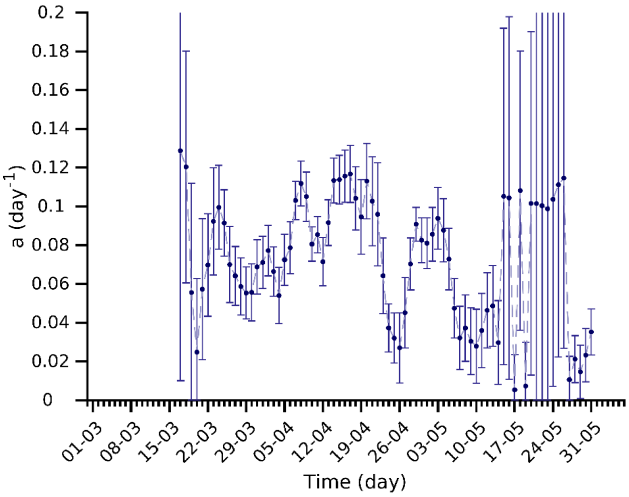


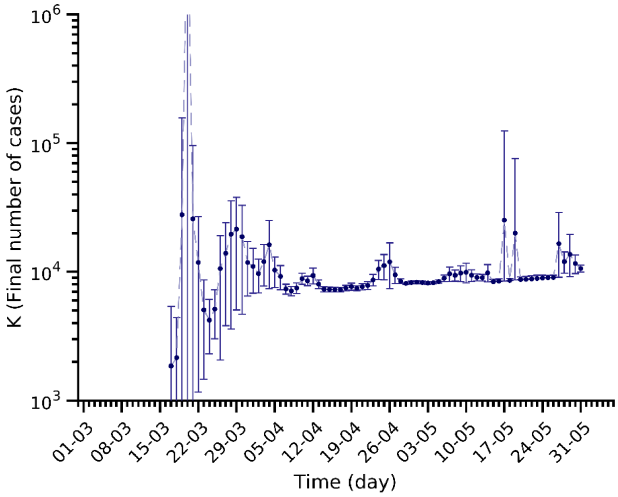


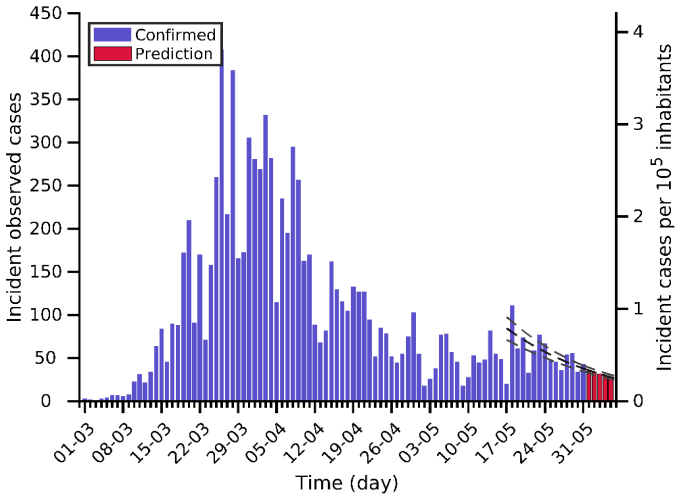
Czech Rep 31-05-2020. Population: 10.7M. Current cumulated incidence: 87/10^5

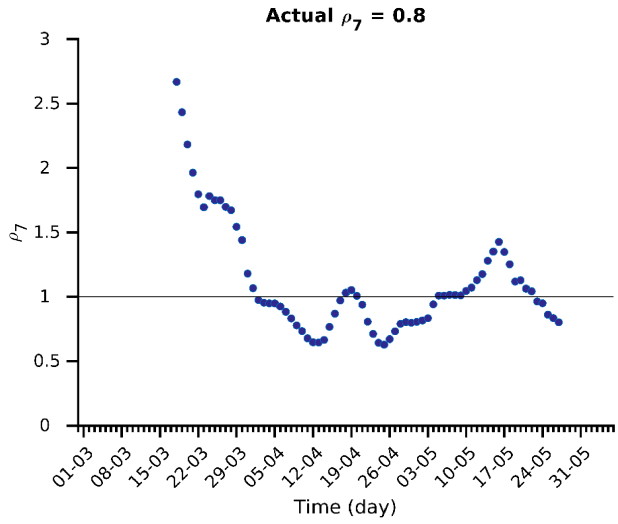


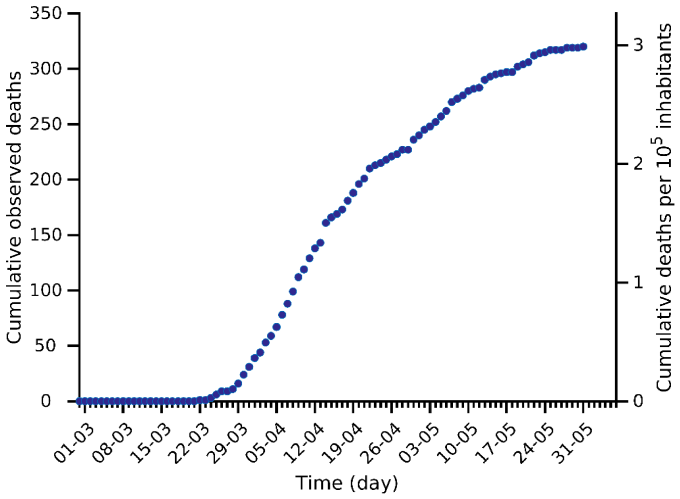


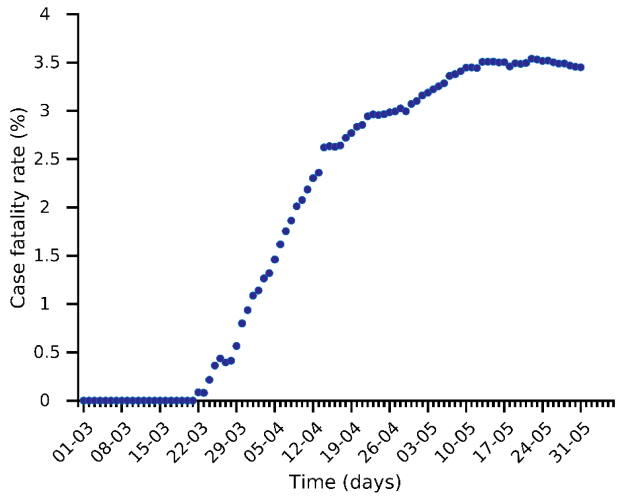




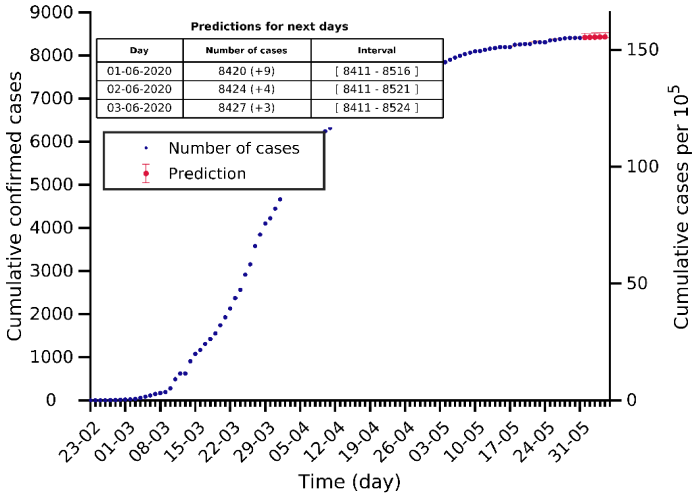


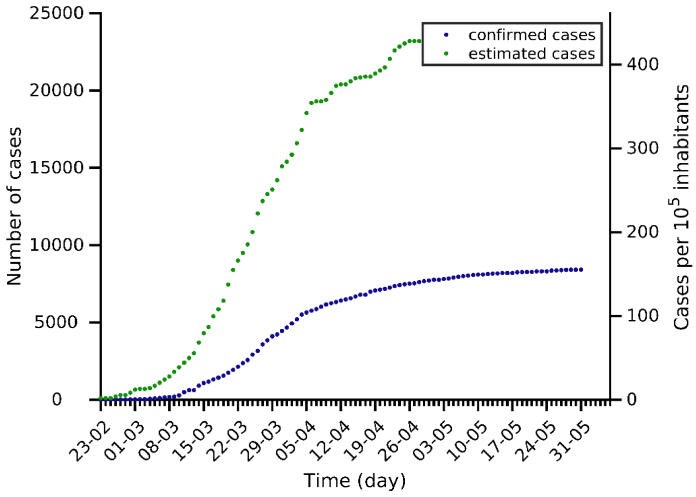


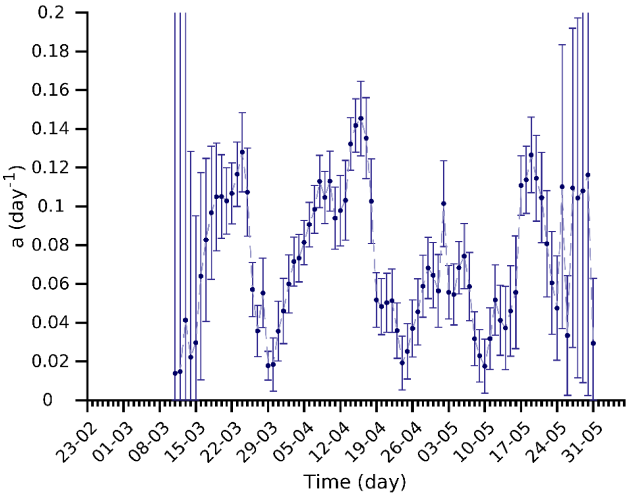


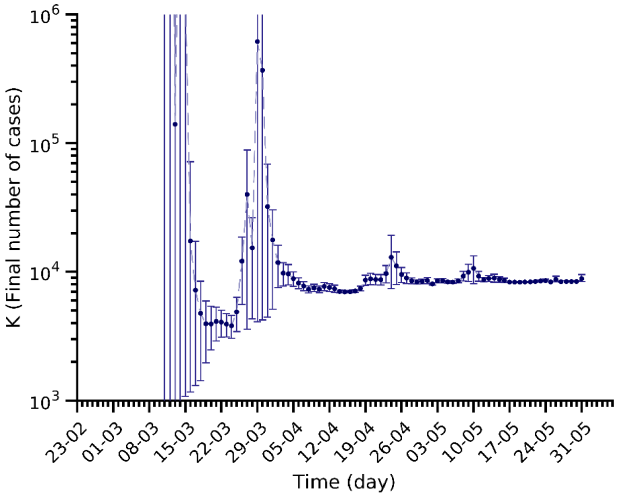


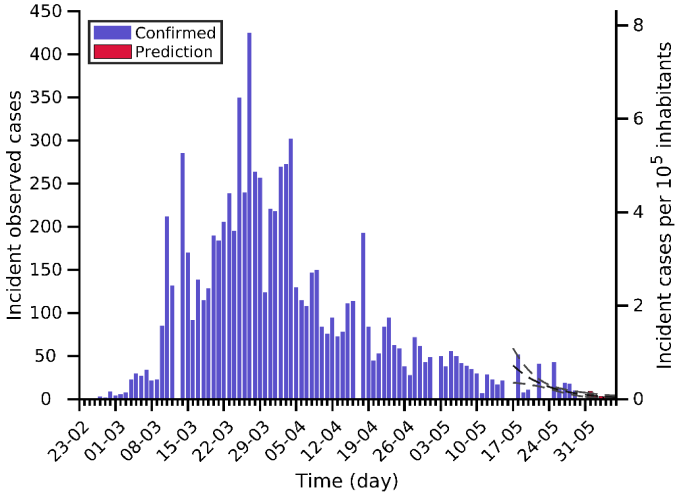
Norway 31-05-2020. Population: 5.4M. Current cumulated incidence: 155/10^5

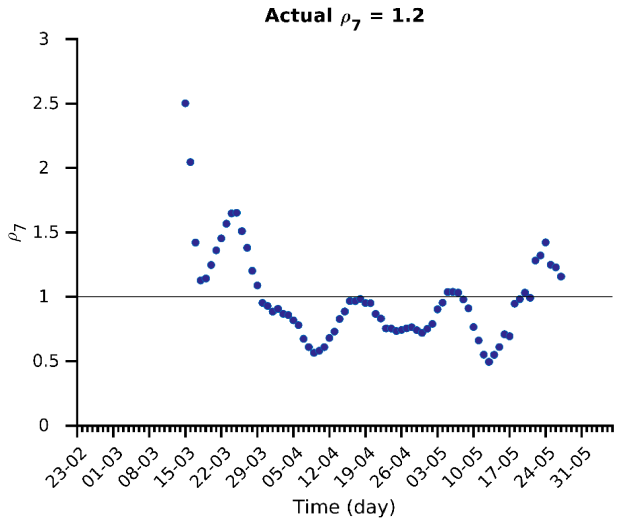


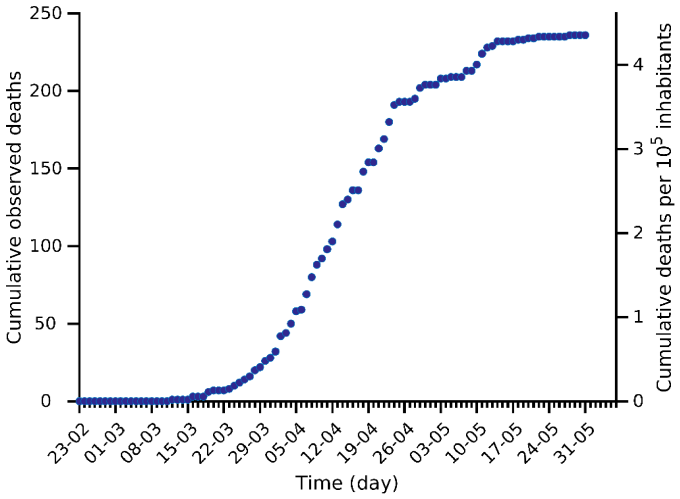


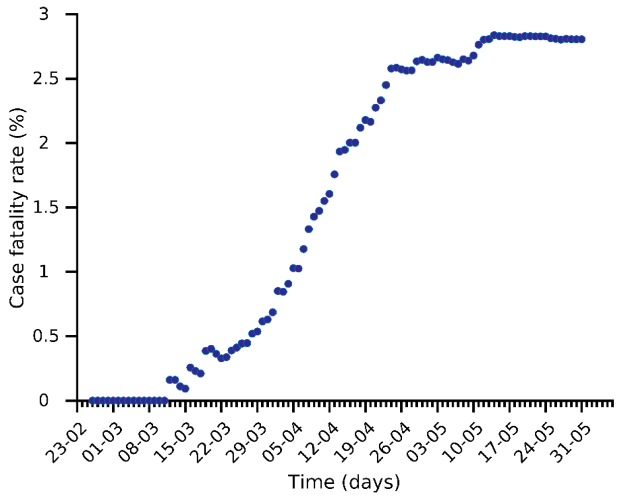




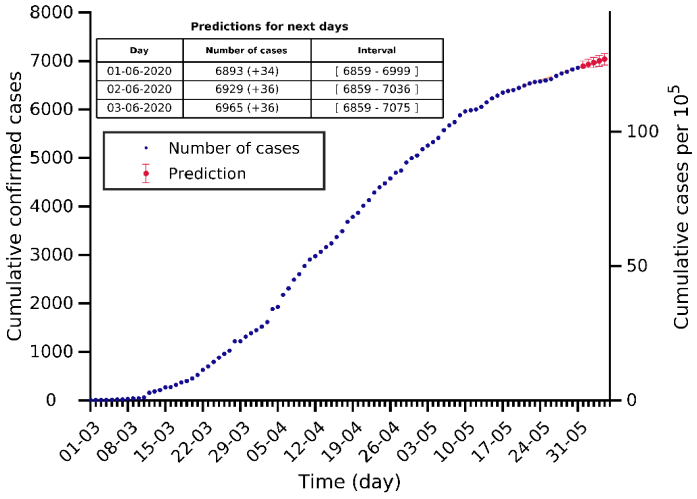


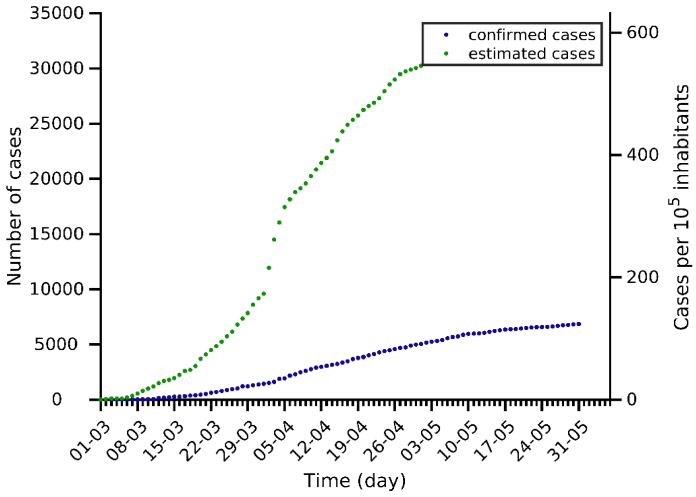


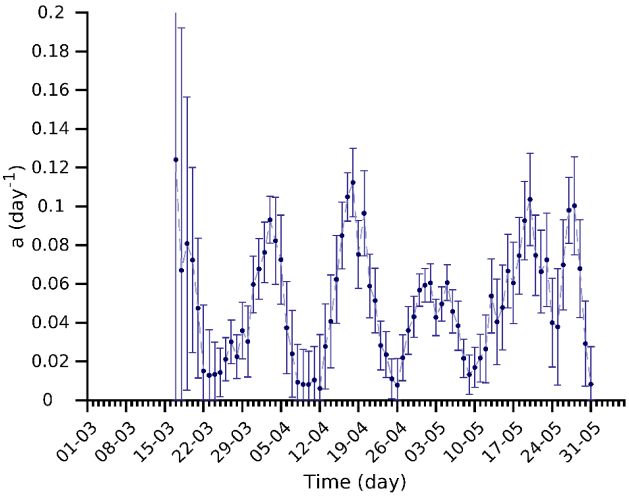


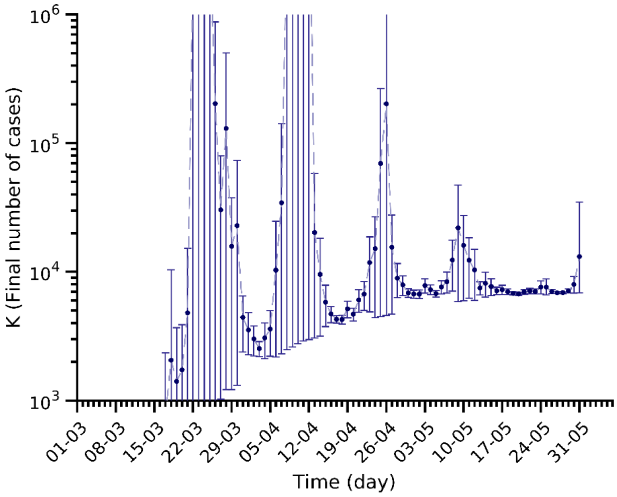


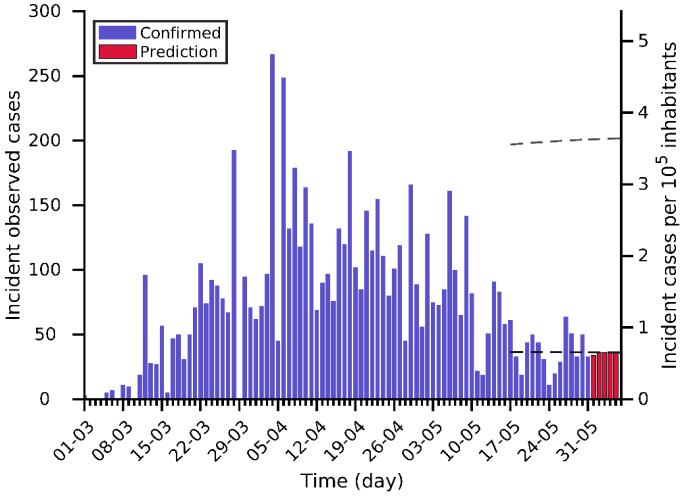
Finland 31-05-2020. Population: 5.5M. Current cumulated incidence: $124/10^5$

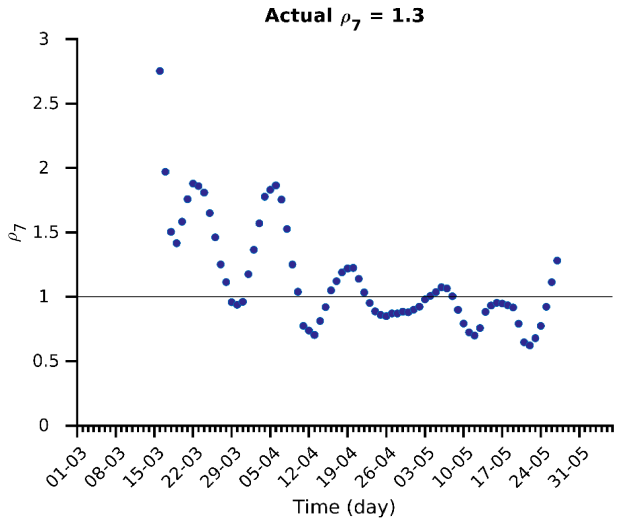


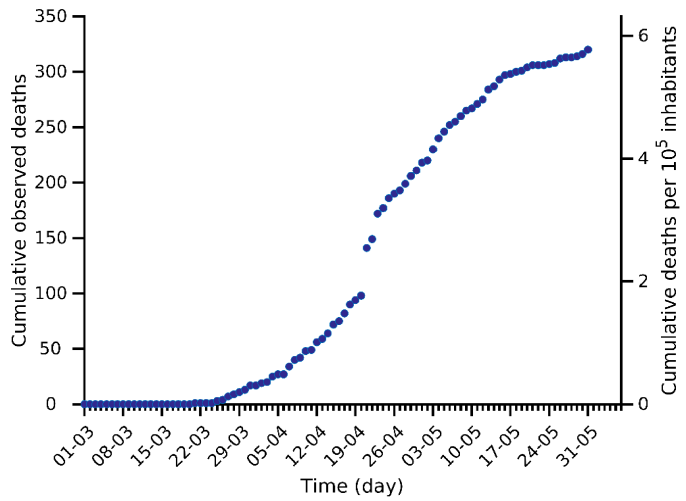


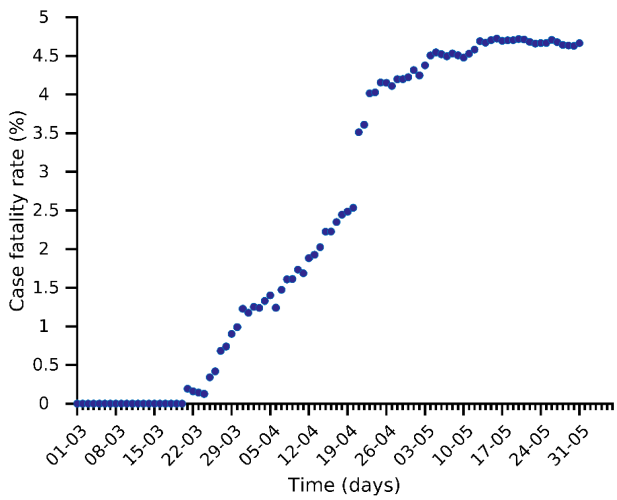




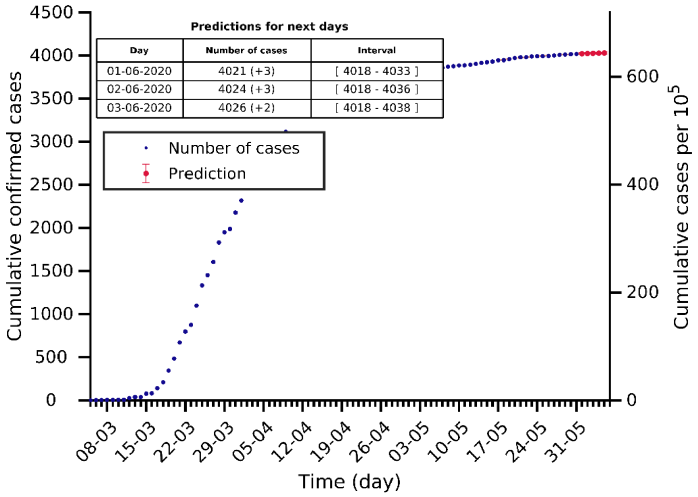


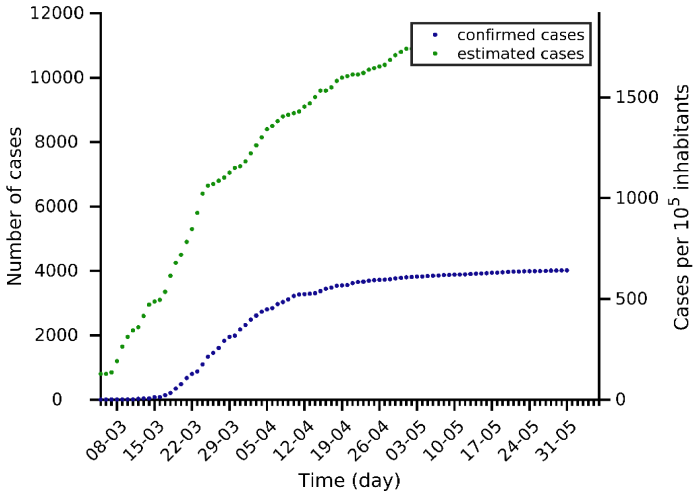


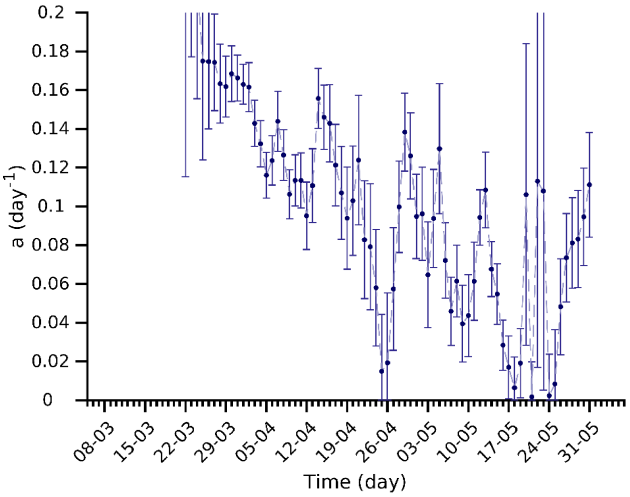


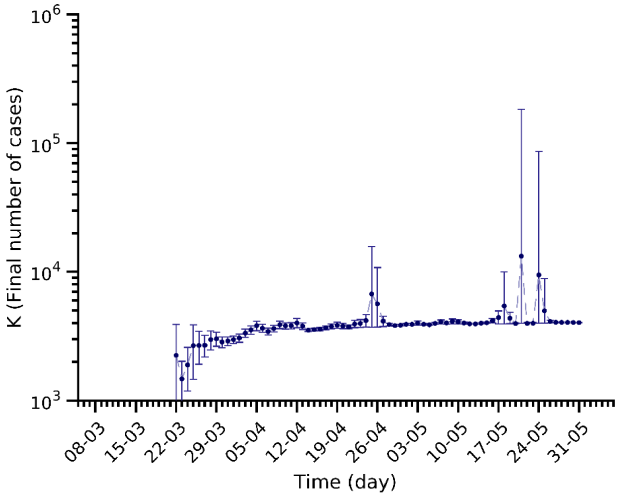


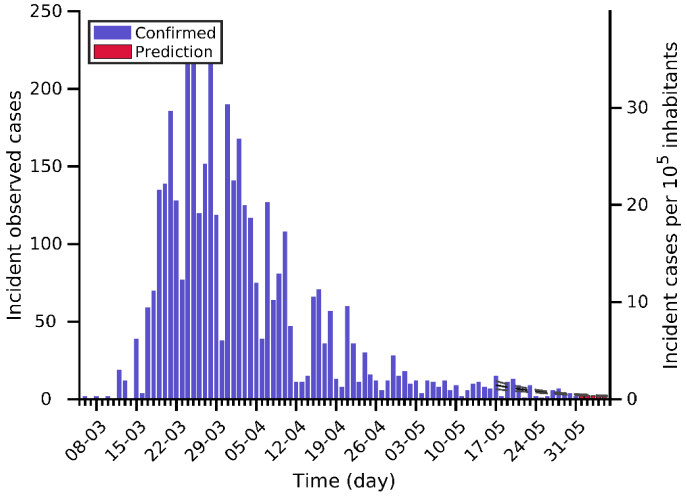
Luxembourg 31-05-2020. Population: 0.6M. Current cumulated incidence: 642/10^5

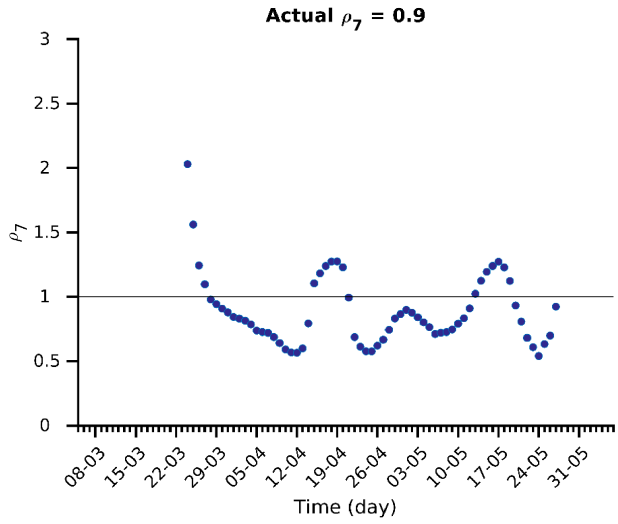


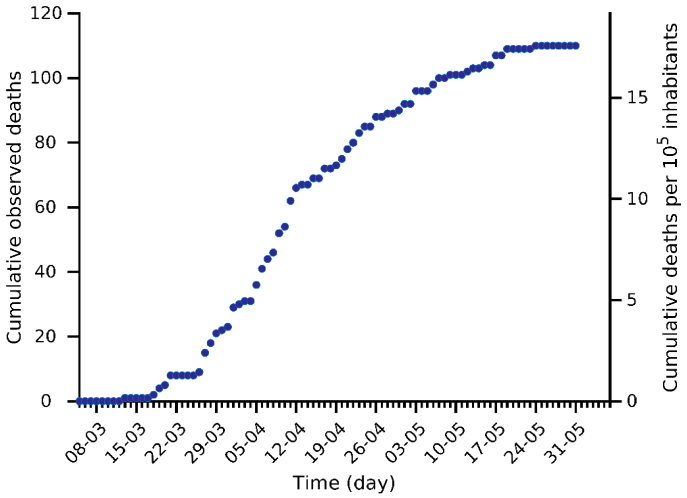


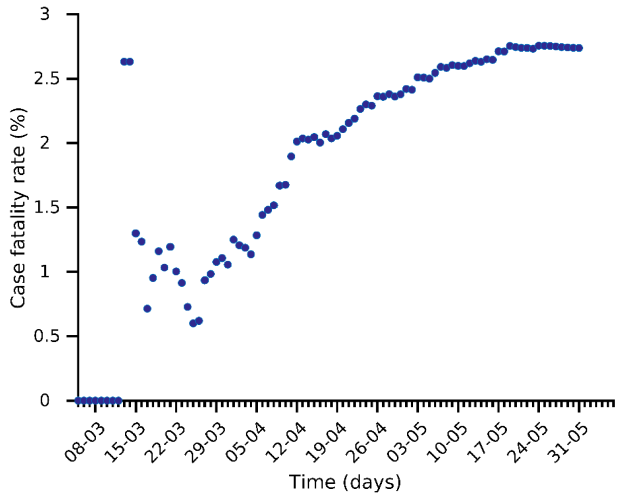




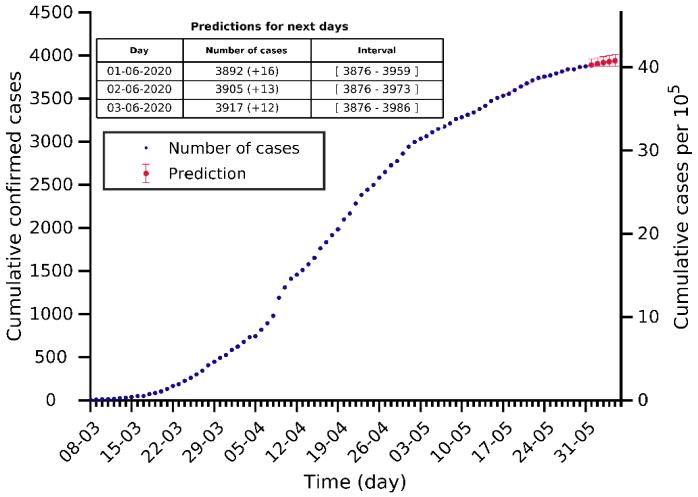


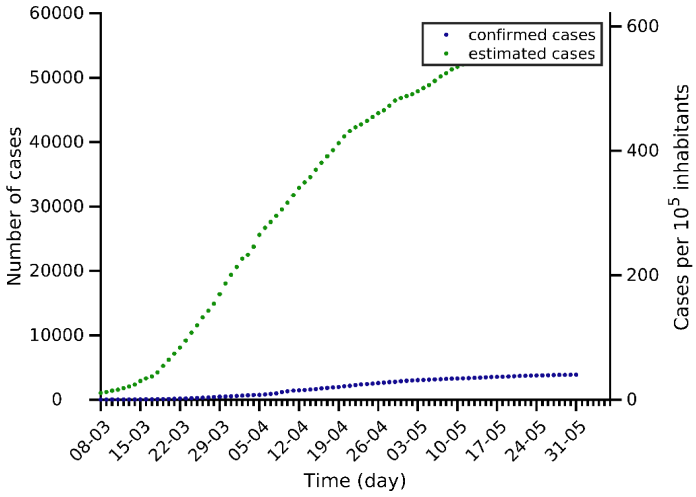


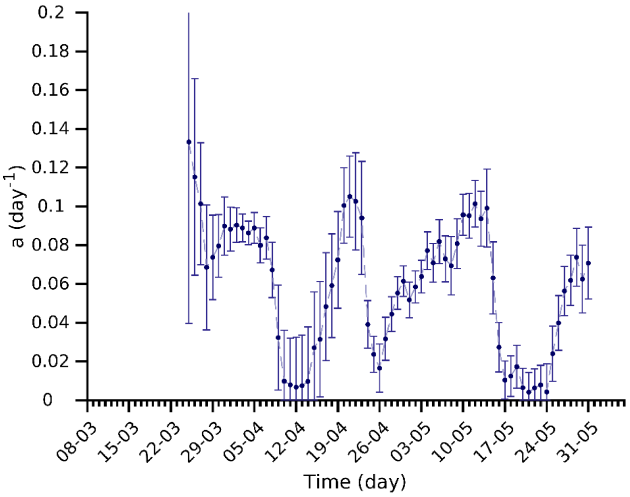


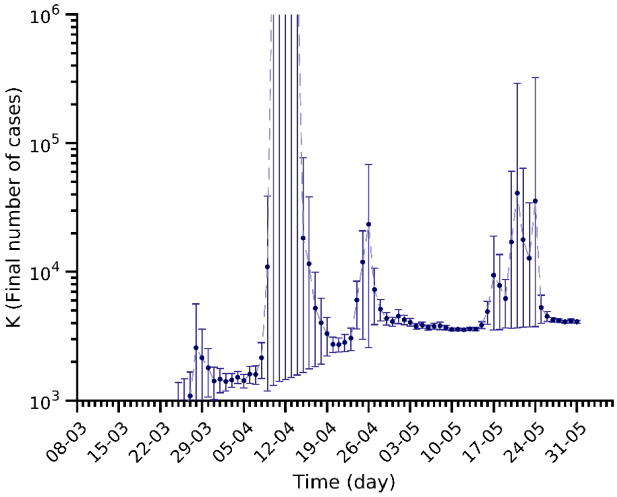


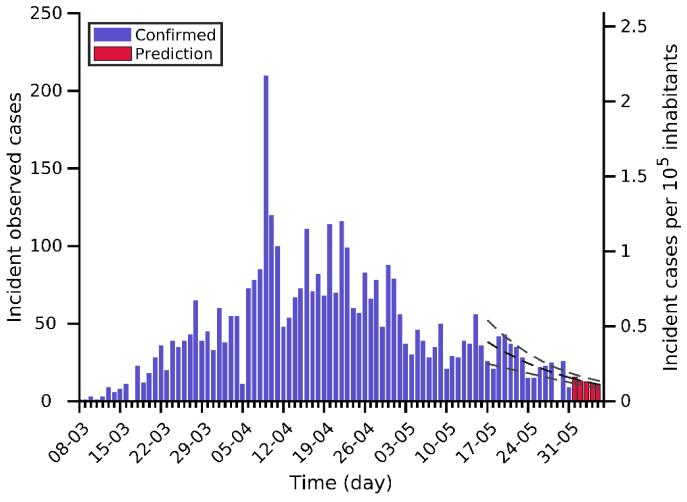
Hungary 31-05-2020. Population: 9.7M. Current cumulated incidence: $40/10^5$

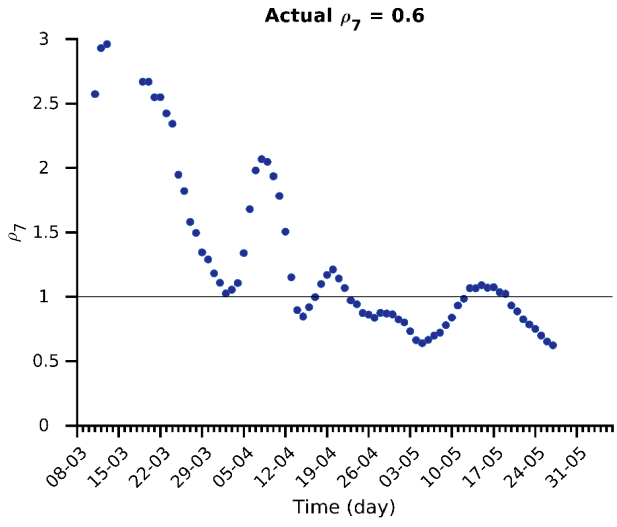


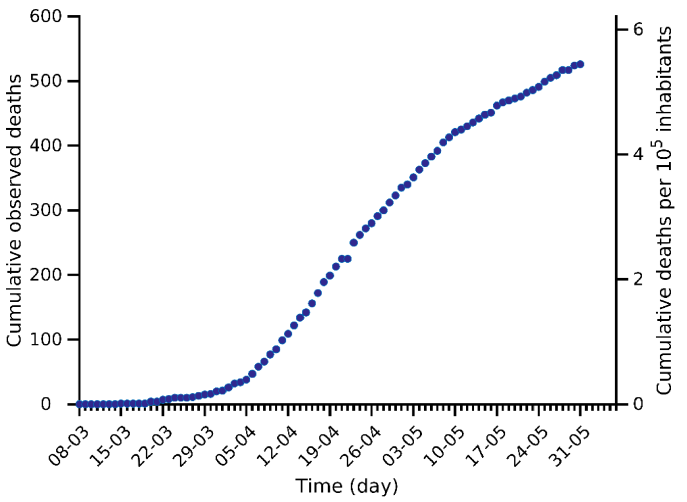


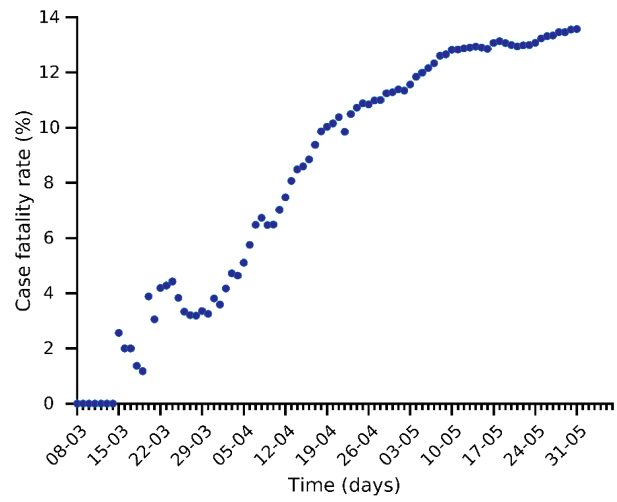




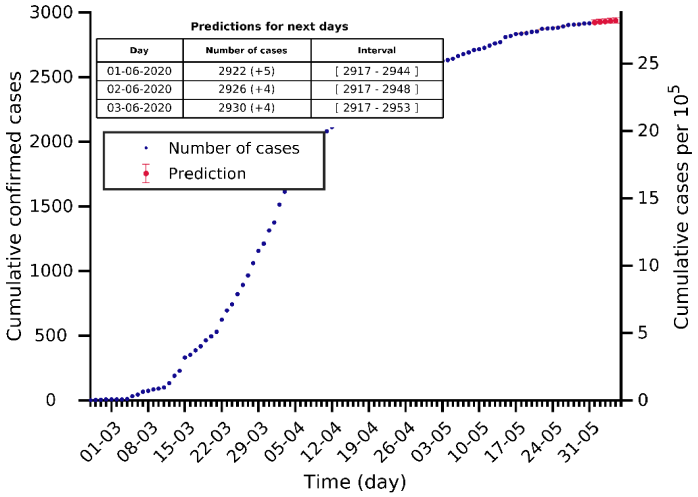


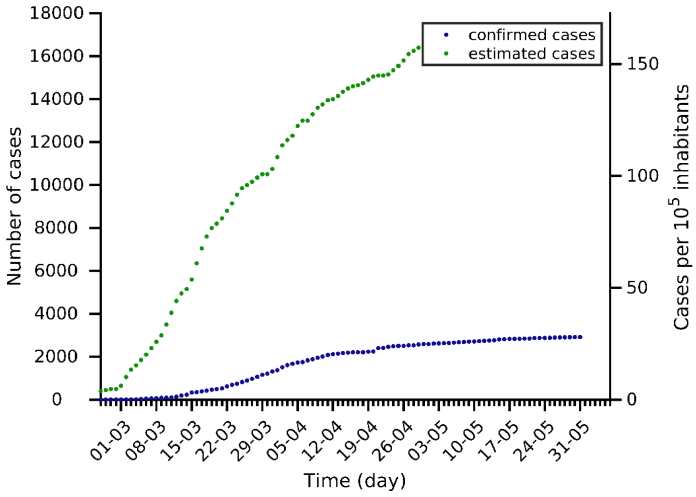


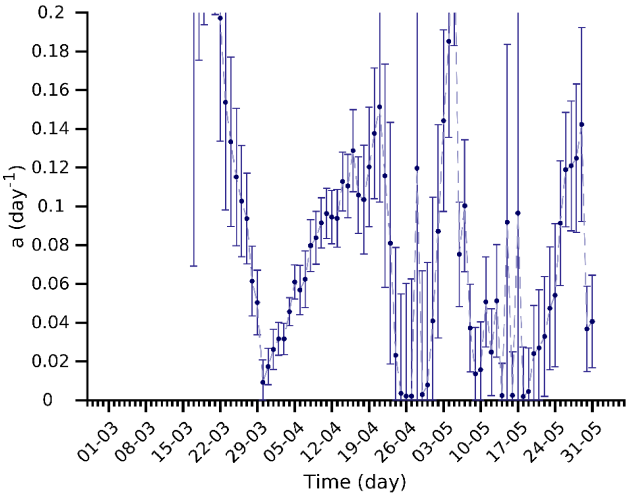


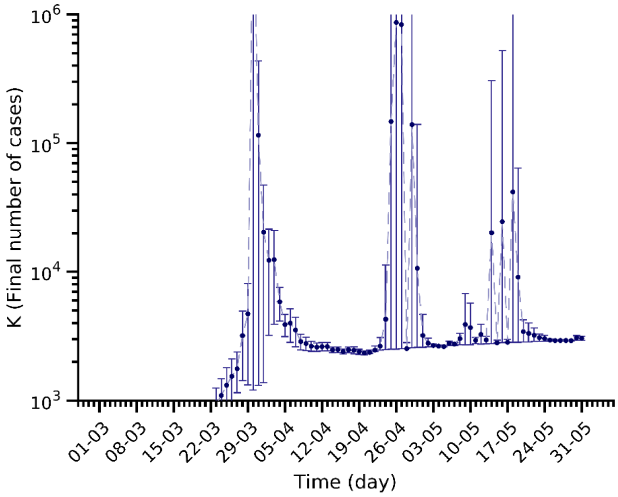


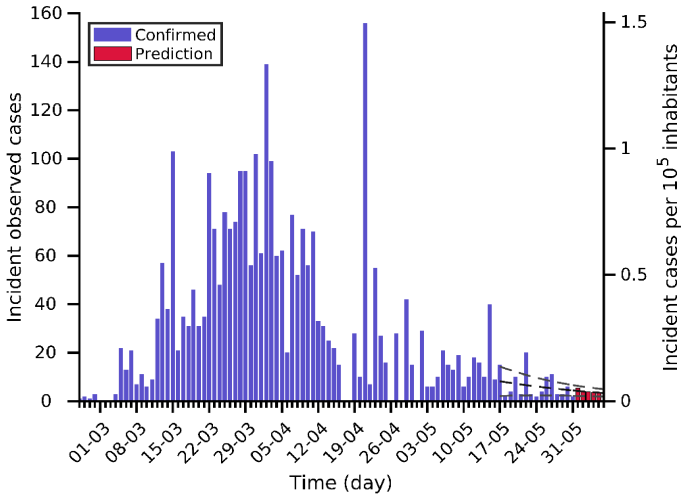
Greece 31-05-2020. Population: 10.4M. Current cumulated incidence: 28/10^5

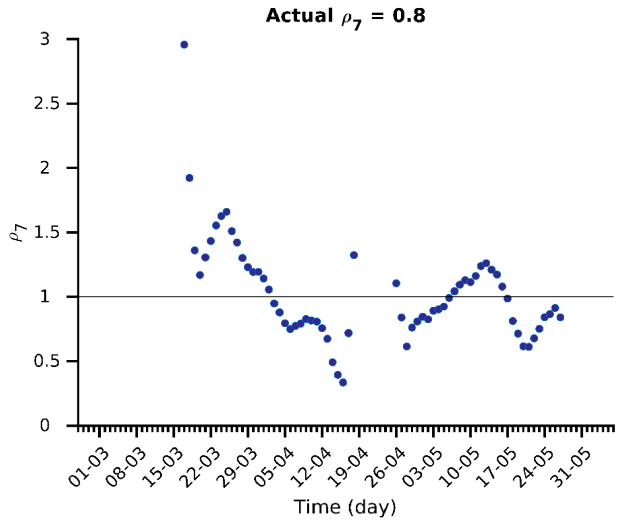


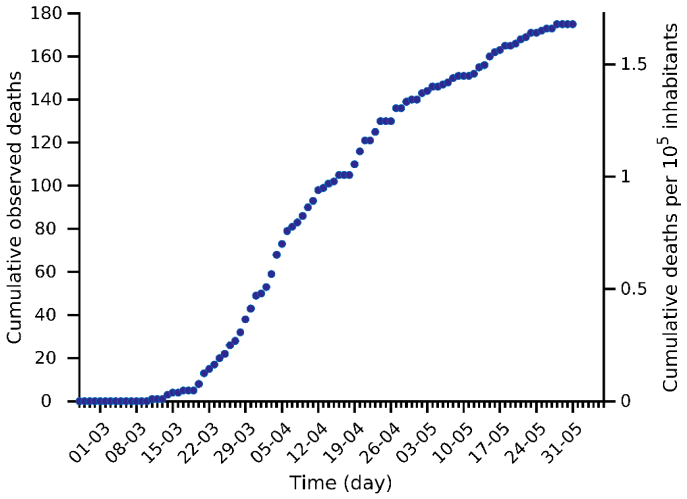


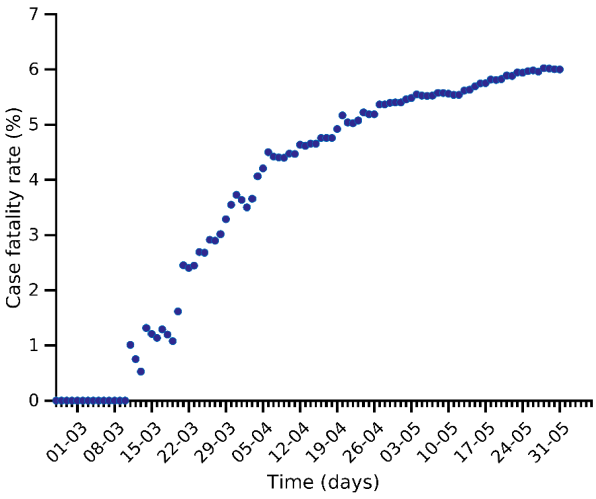




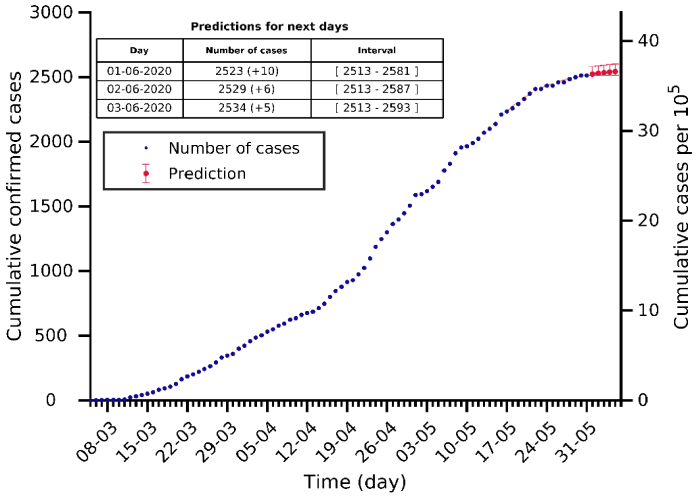


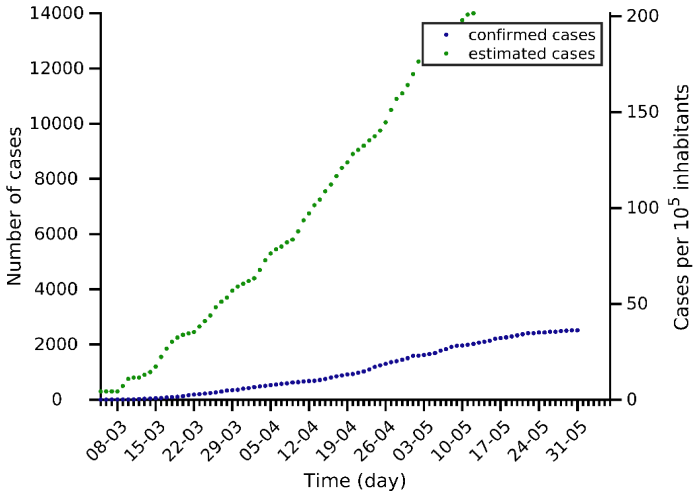


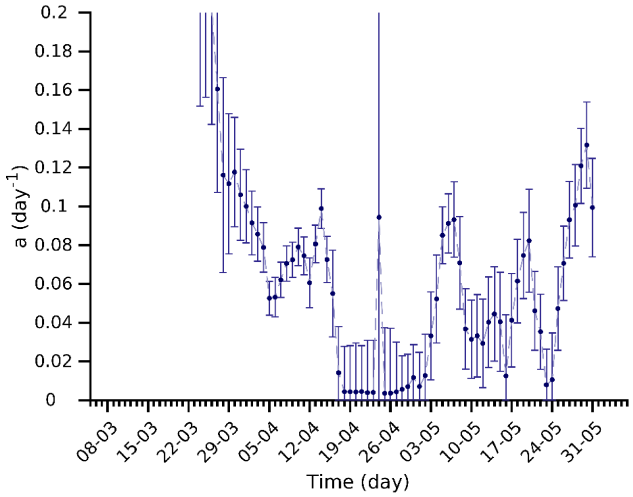


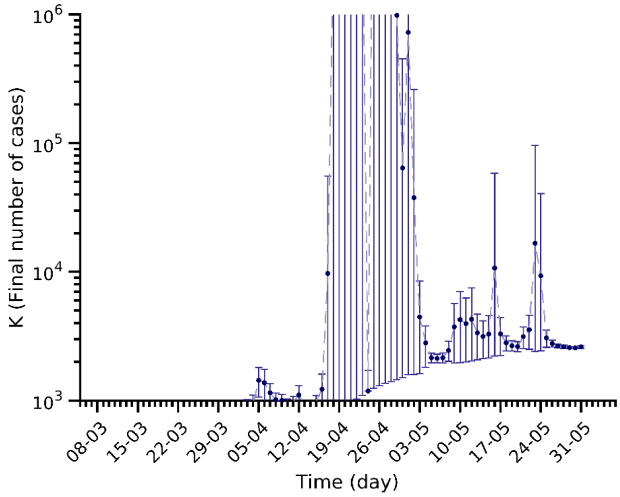


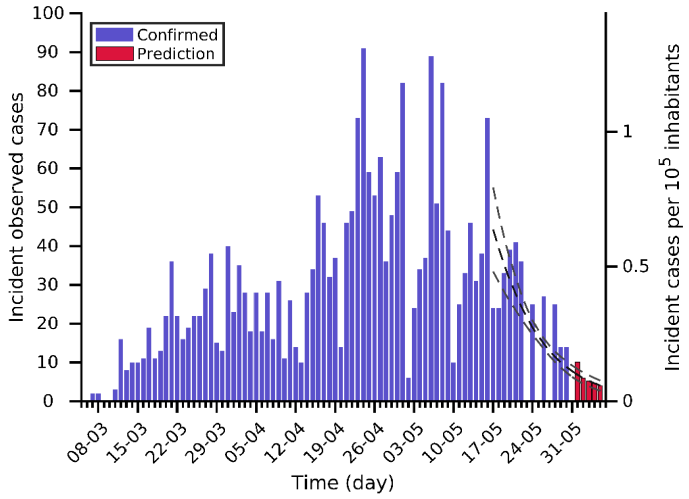
Bulgaria 31-05-2020. Population: 6.9M. Current cumulated incidence: $36/10^5$

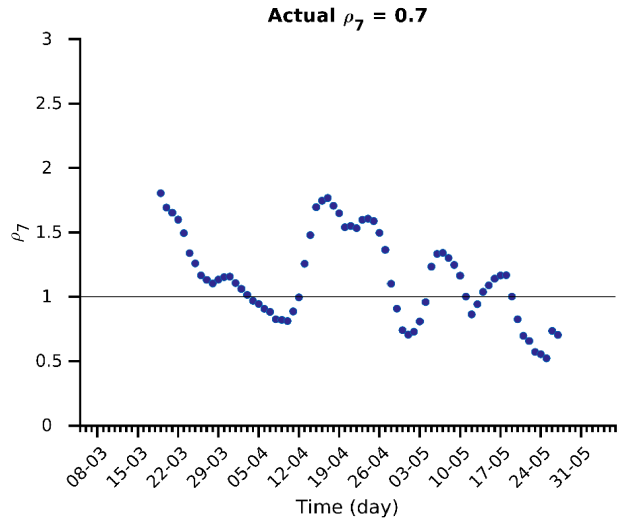


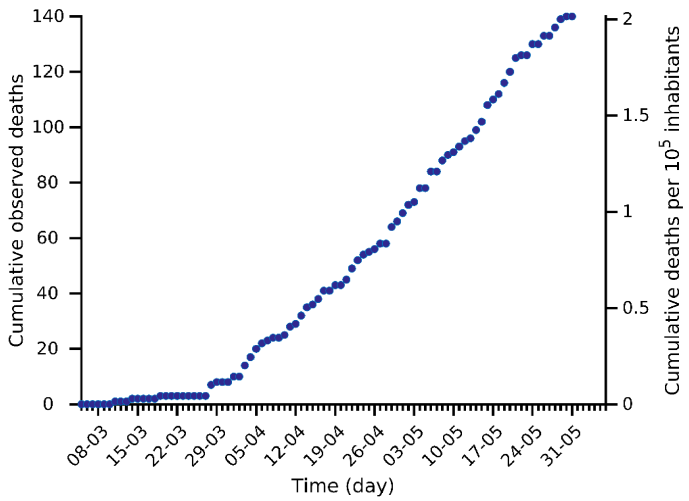


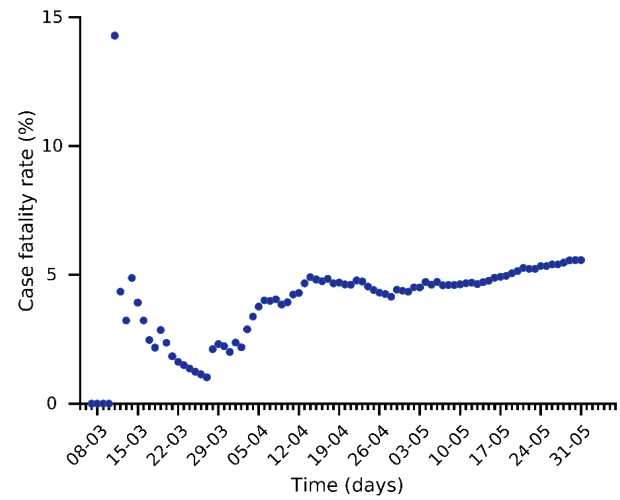




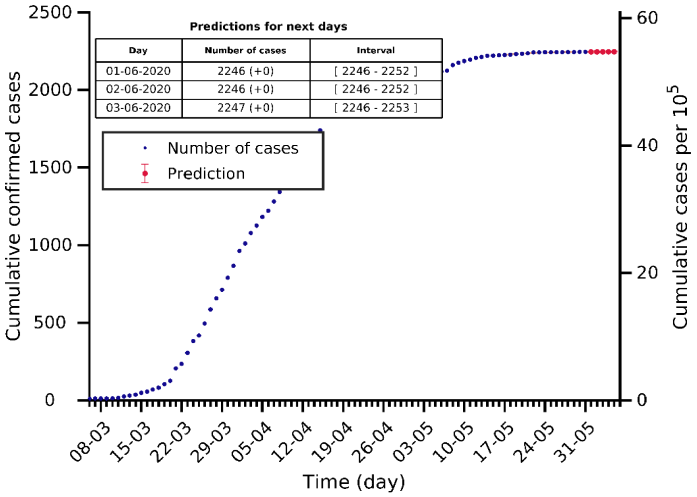


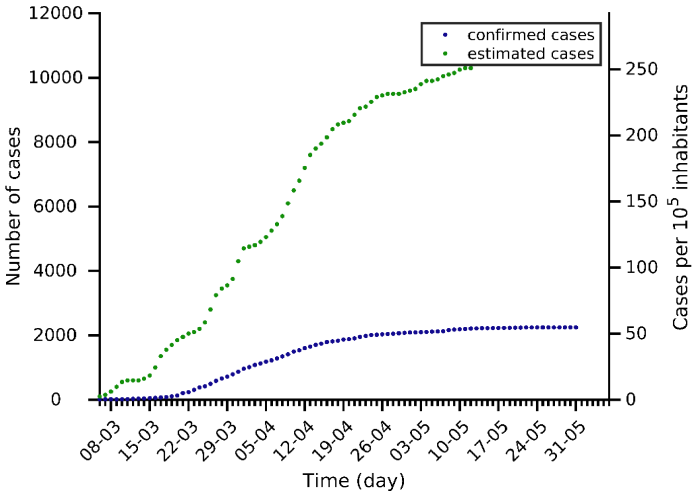


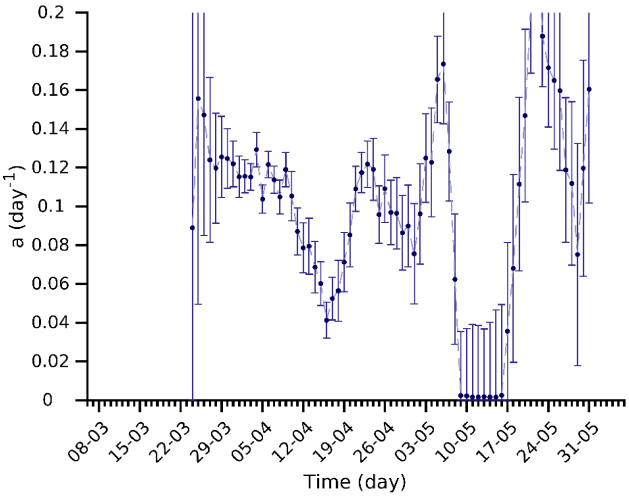


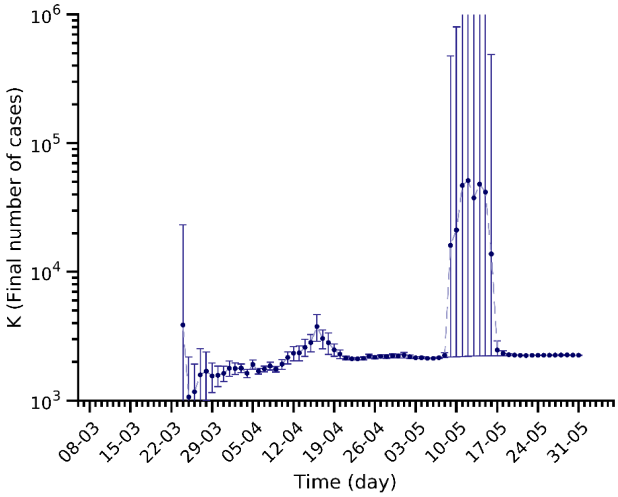


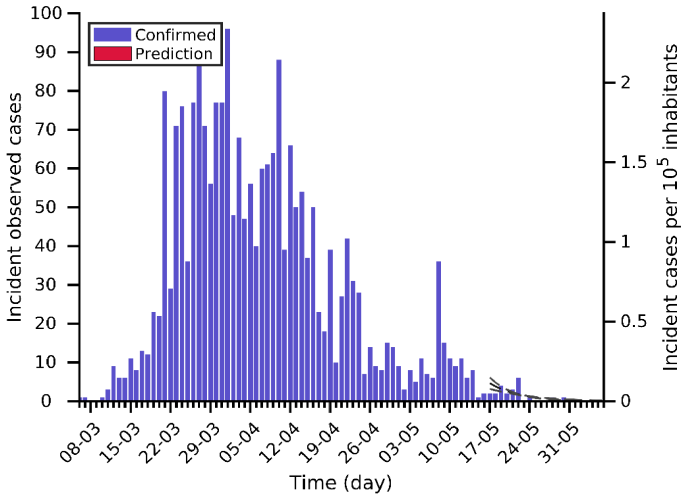
Croatia 31-05-2020. Population: 4.1M. Current cumulated incidence: $55/10^5$

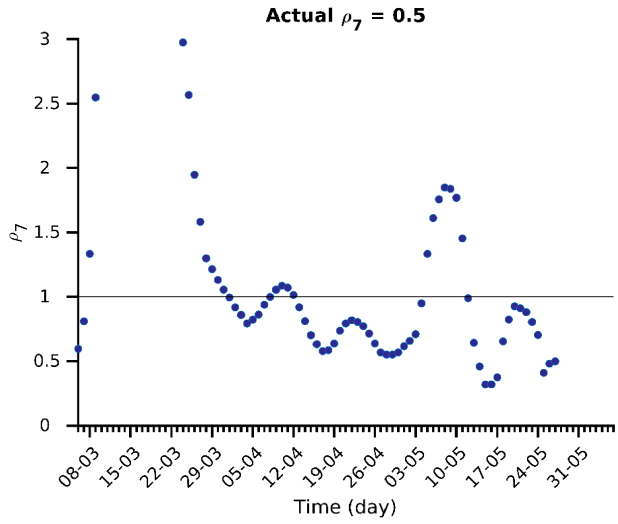


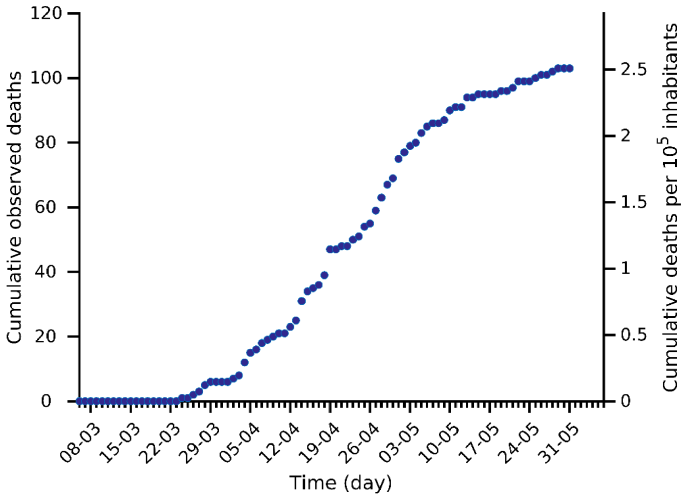


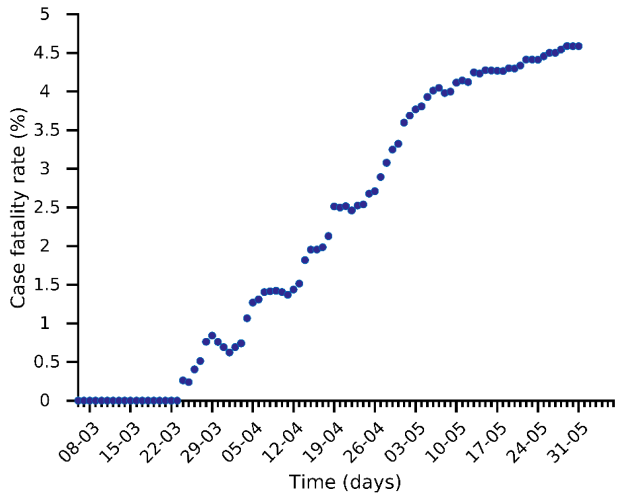




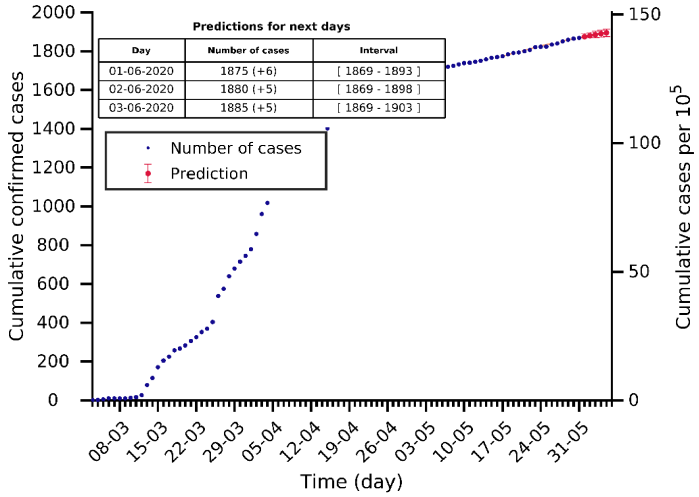


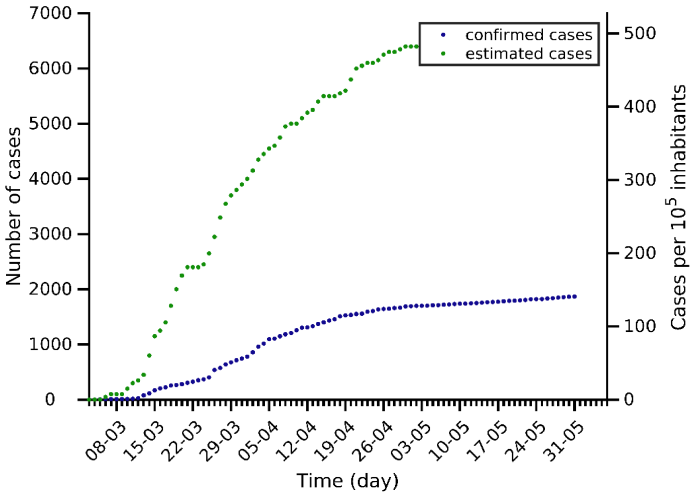


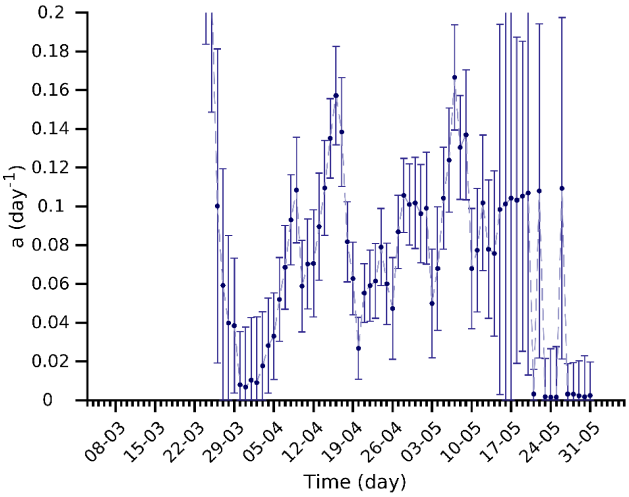


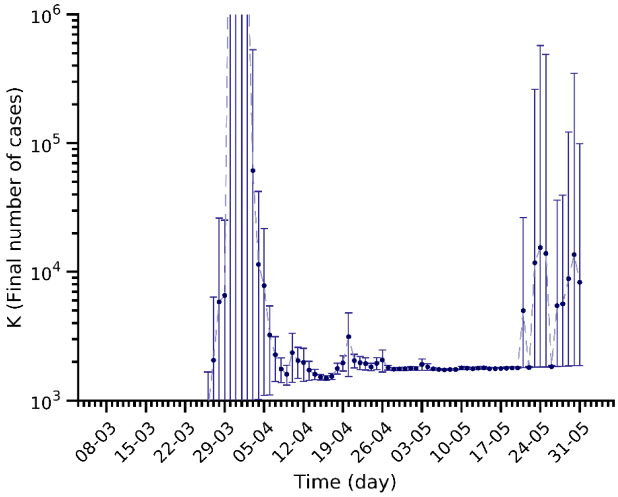


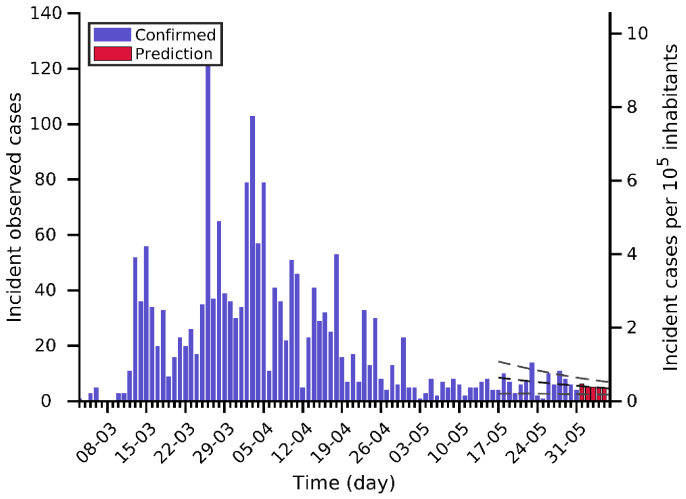
Estonia 31-05-2020. Population: 1.3M. Current cumulated incidence: $141/10^5$

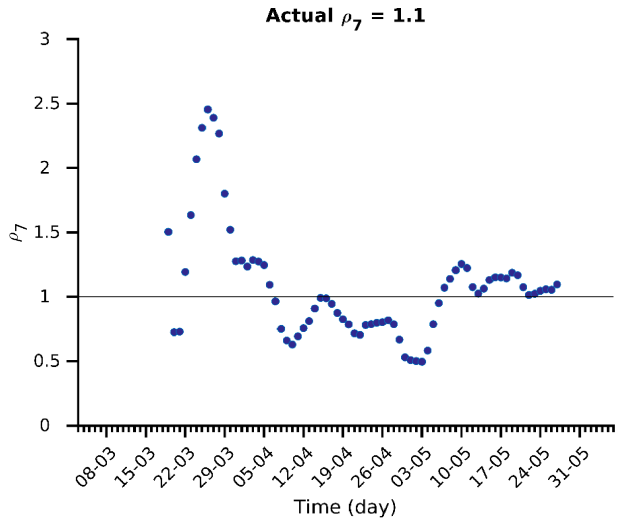


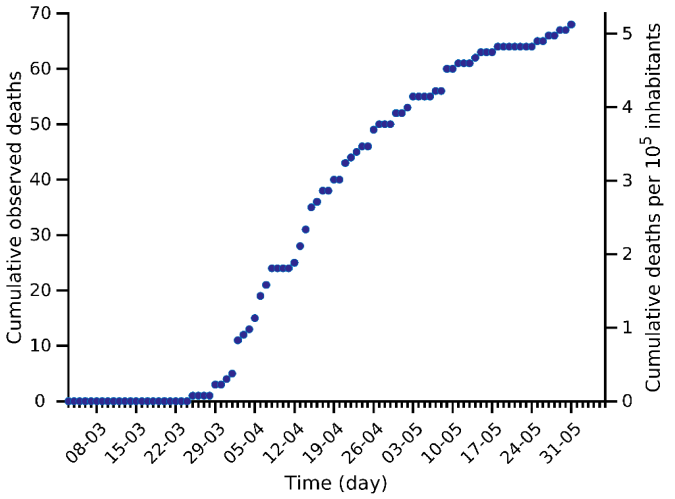


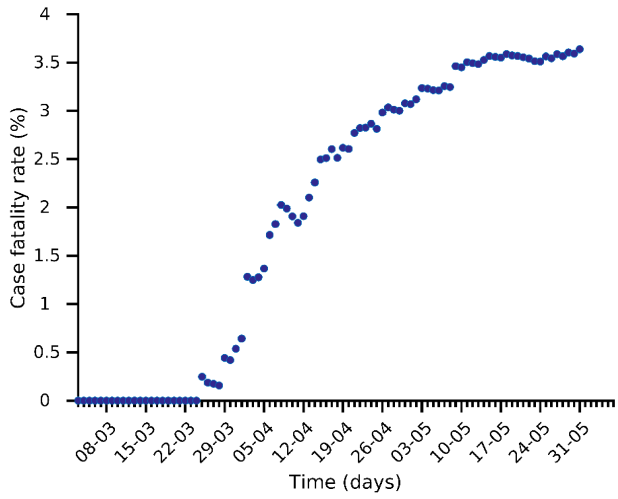




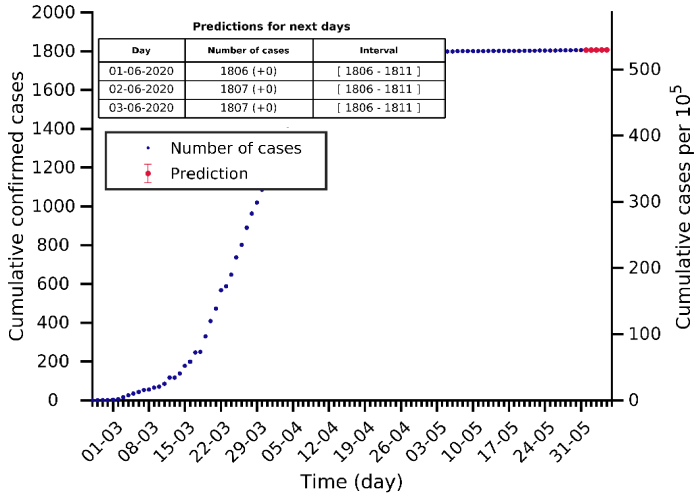


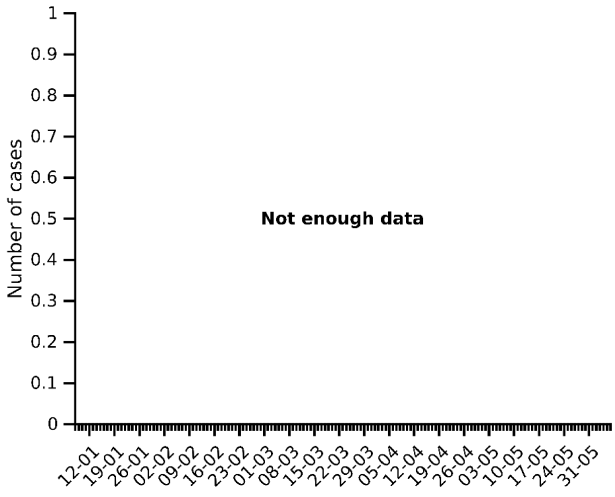


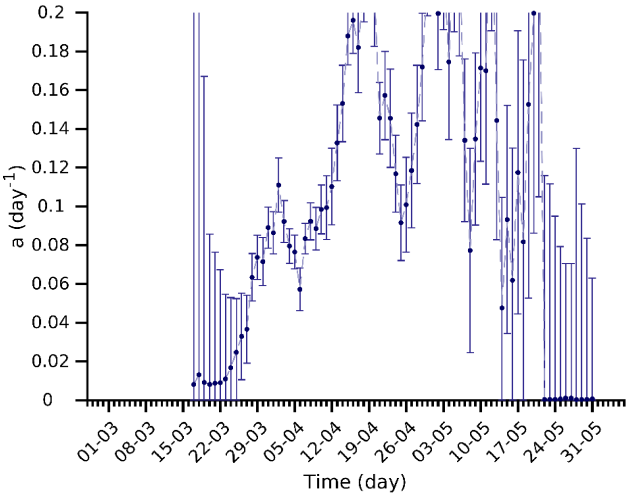


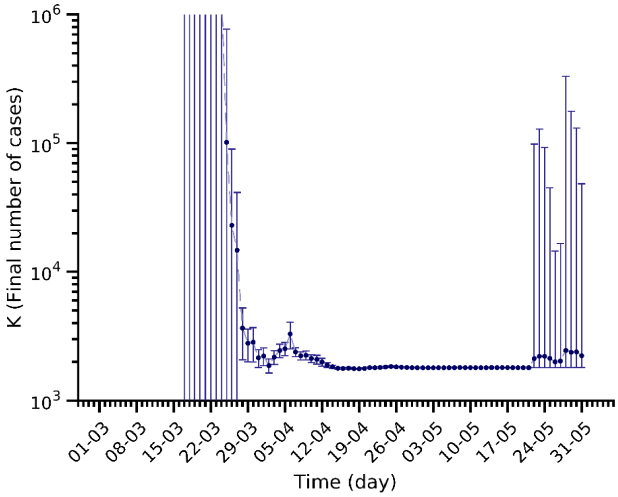


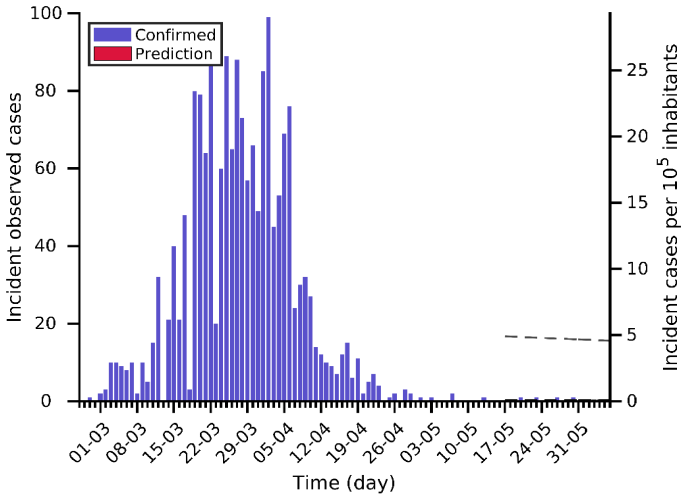
Iceland 31-05-2020. Population: 0.3M. Current cumulated incidence: $529/10^5$

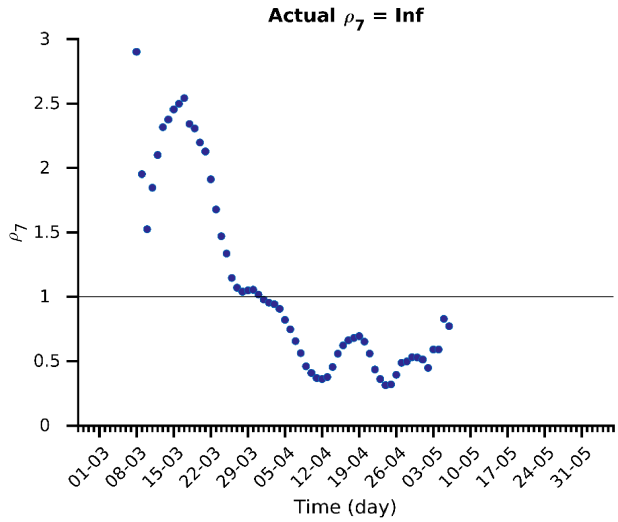


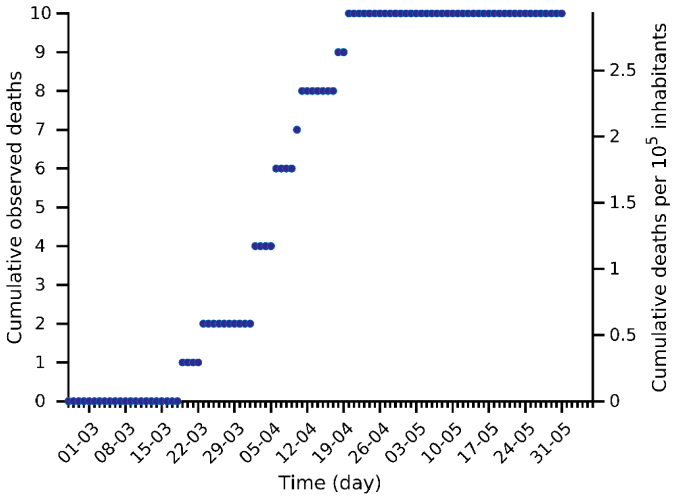


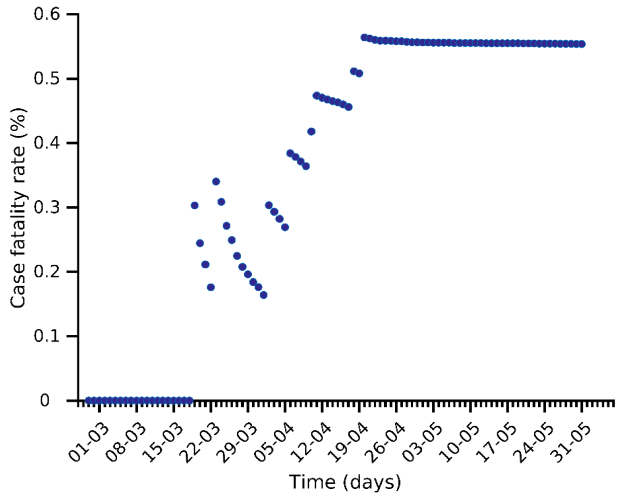




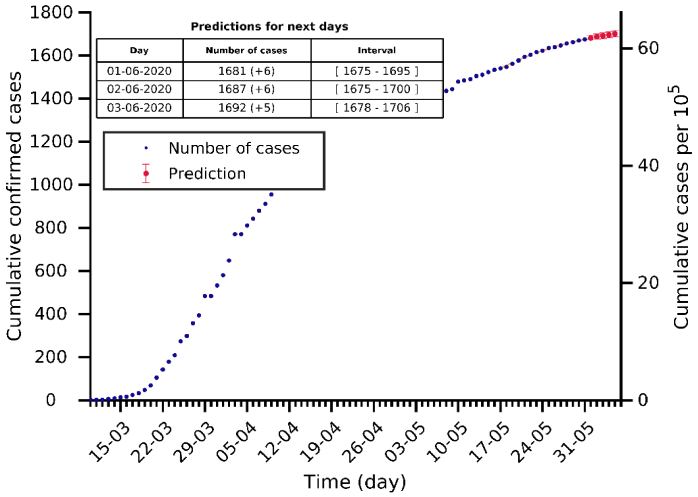


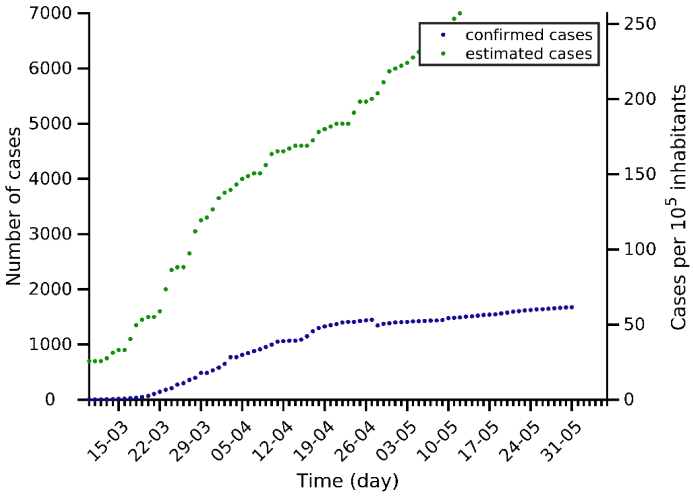


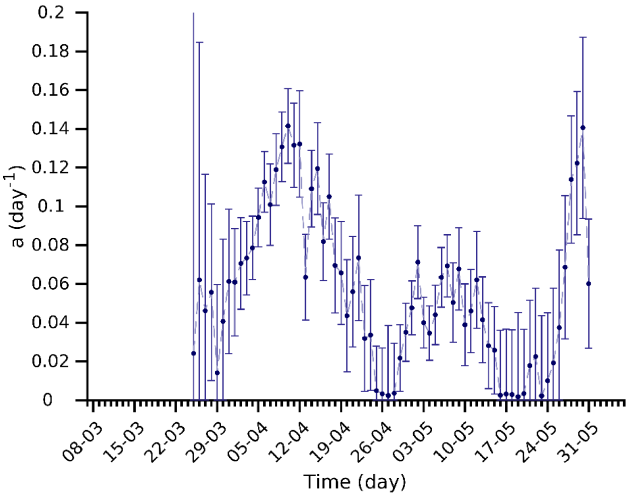


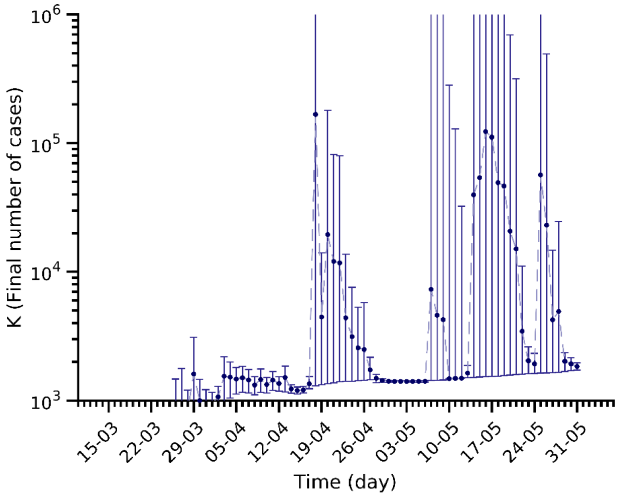


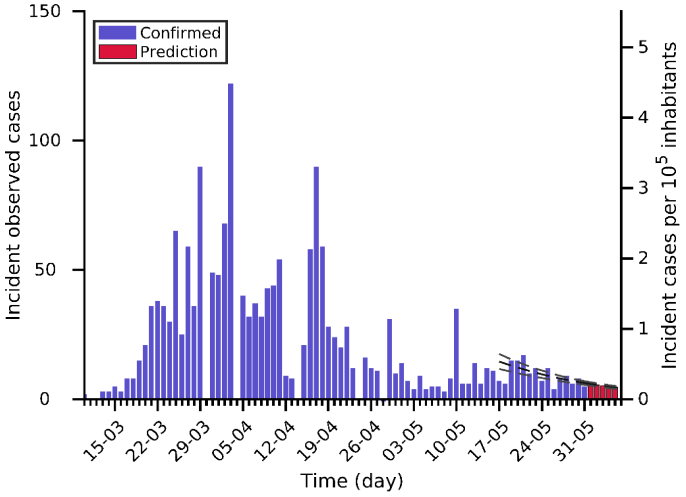
Lithuania 31-05-2020. Population: 2.7M. Current cumulated incidence: 62/10^5

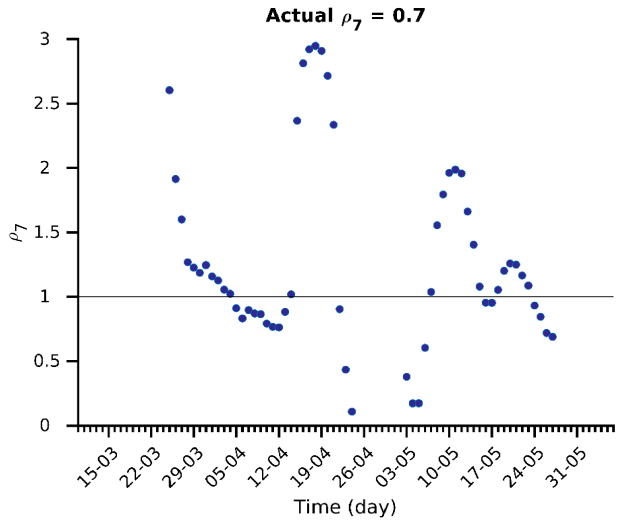


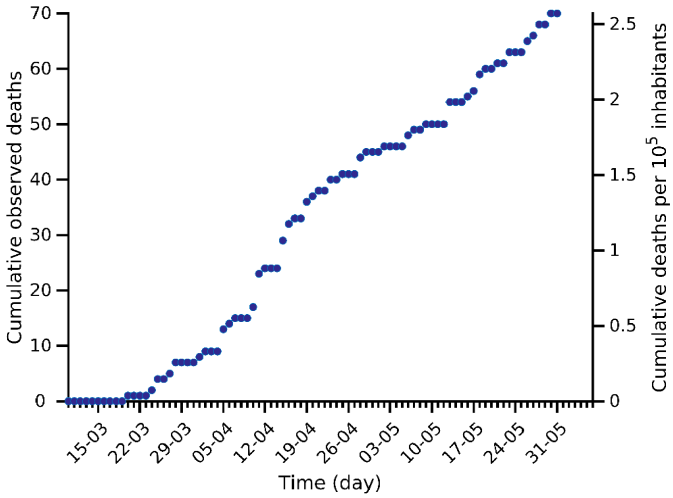


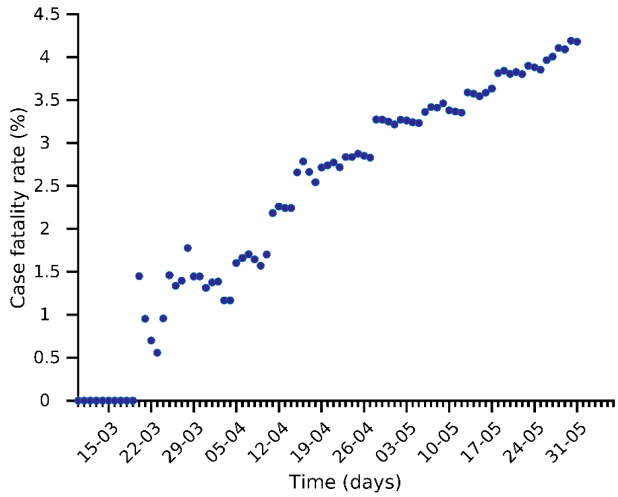




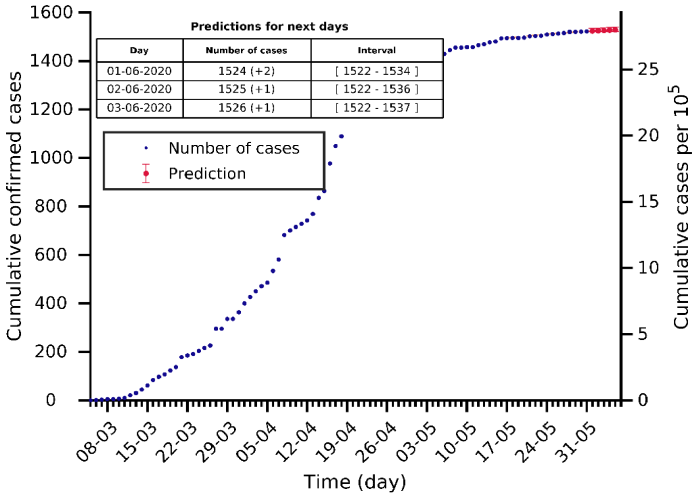


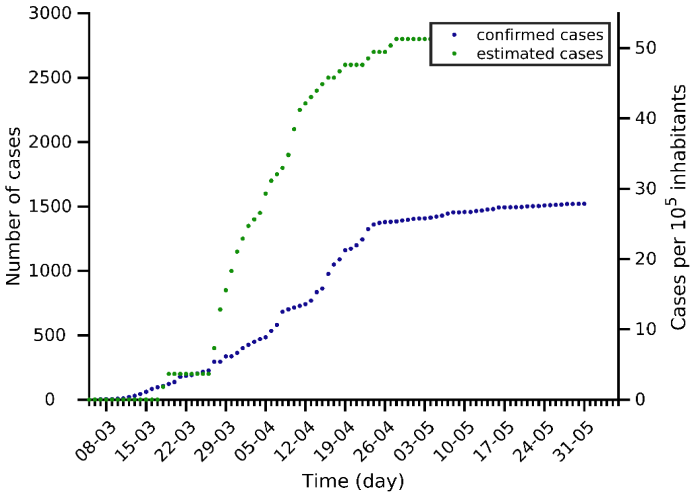


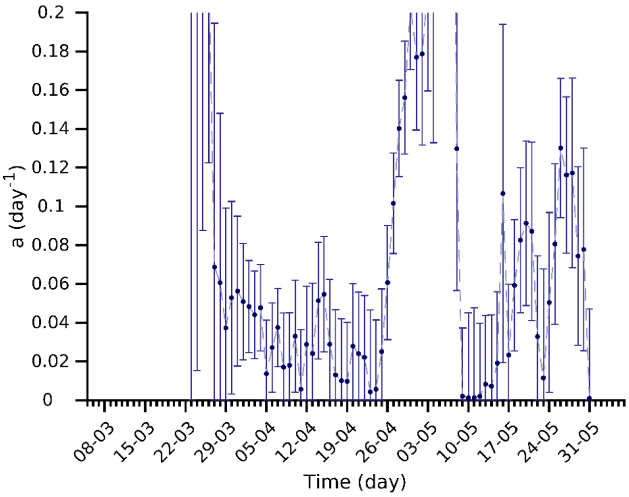


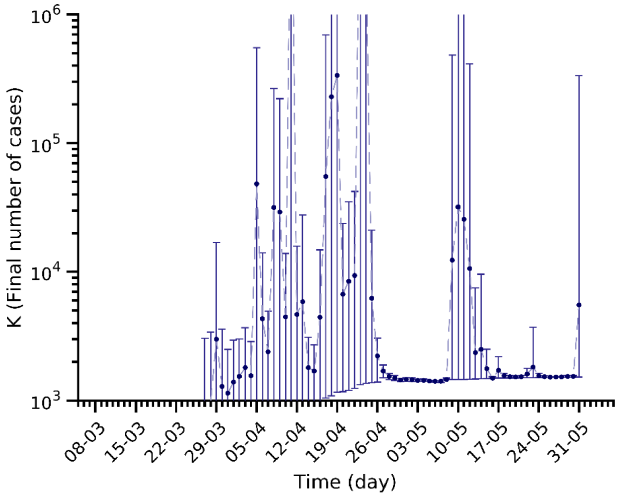


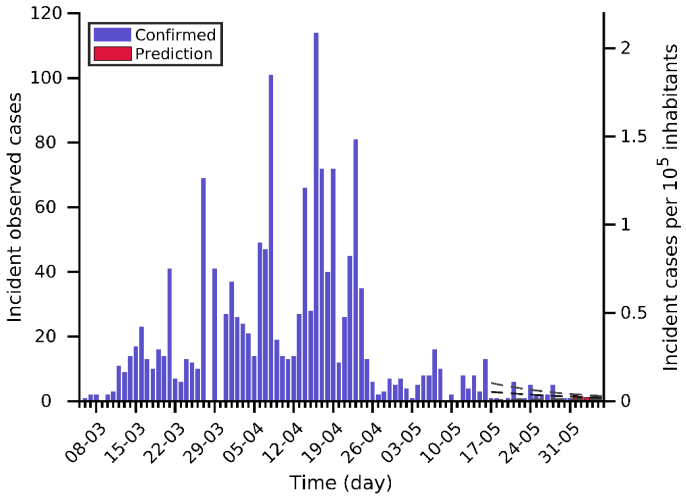
Slovakia 31-05-2020. Population: 5.5M. Current cumulated incidence: 28/10^5

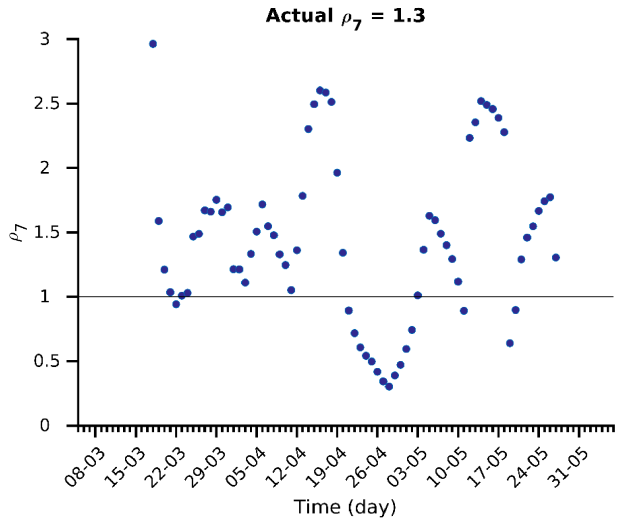


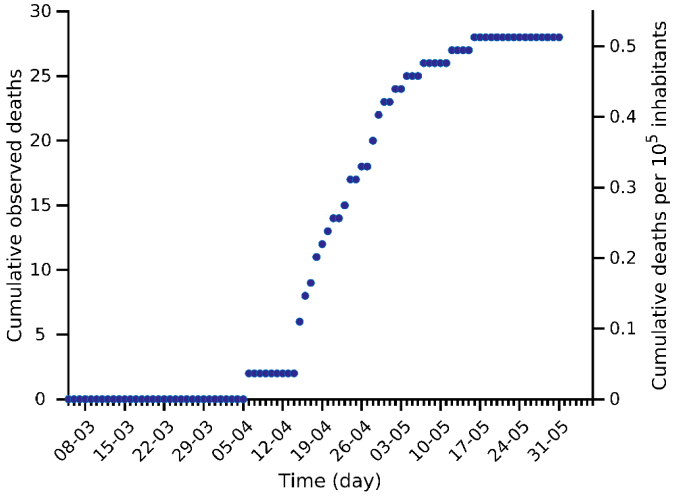


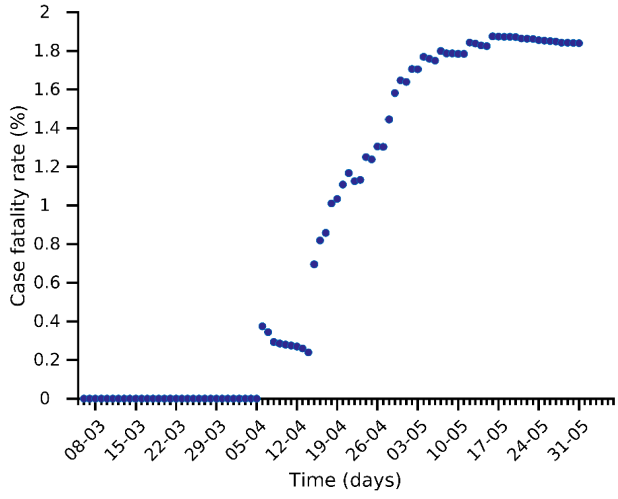




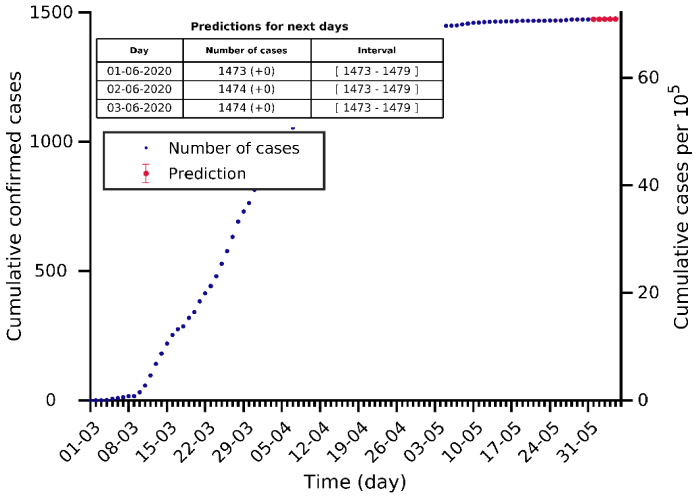


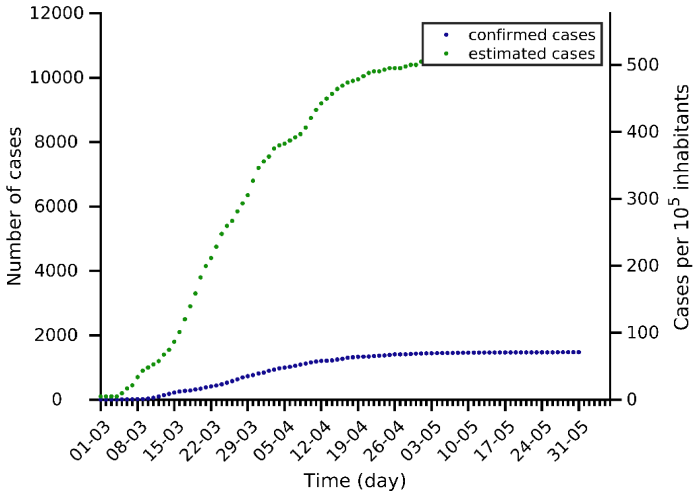


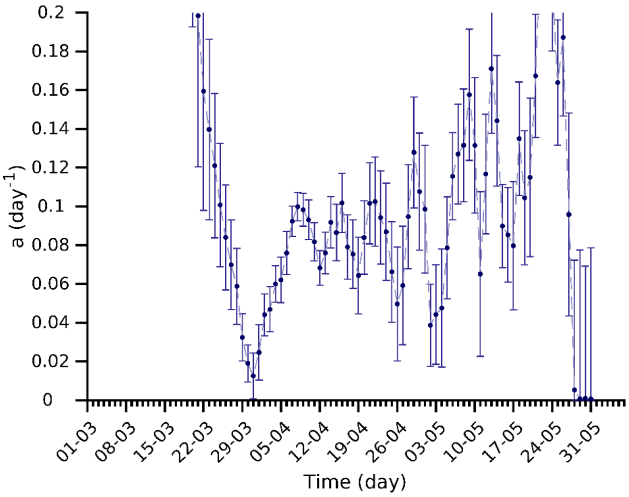


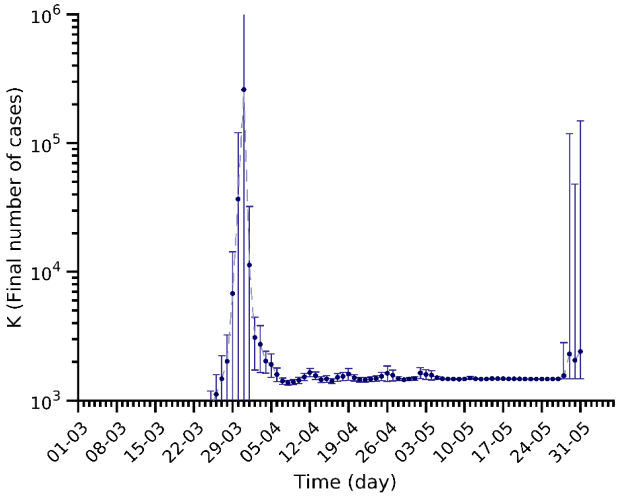


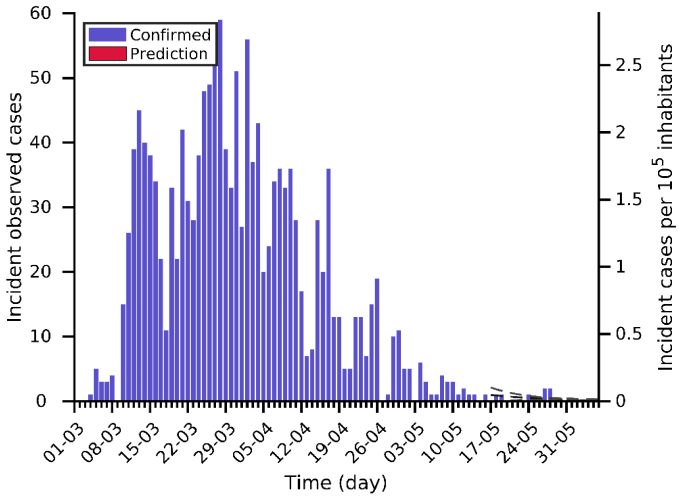
Slovenia 31-05-2020. Population: 2.1M. Current cumulated incidence: 71/10^5

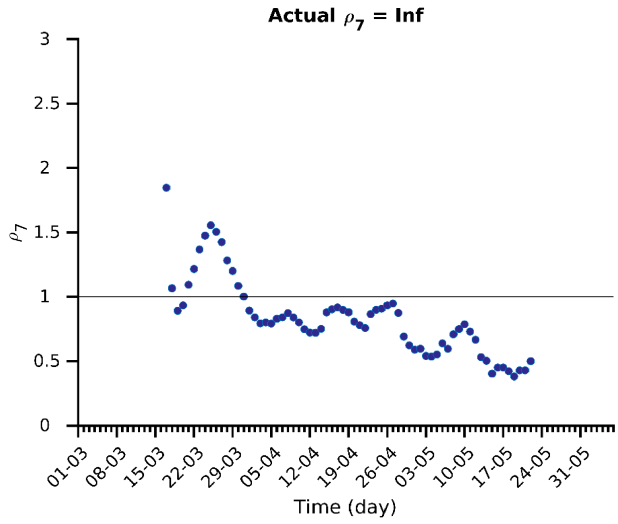


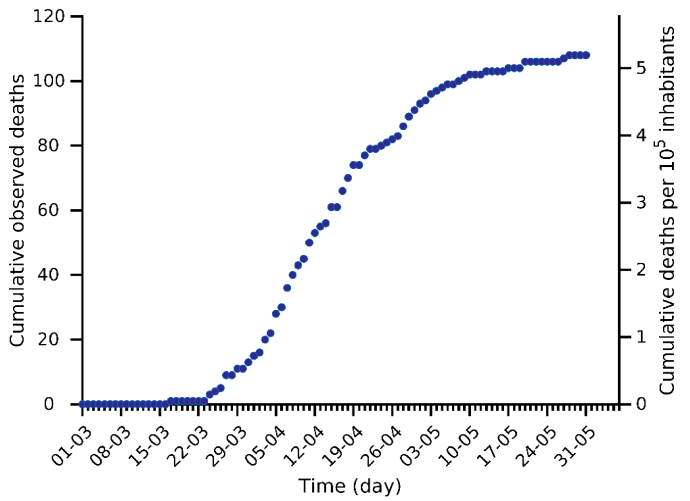


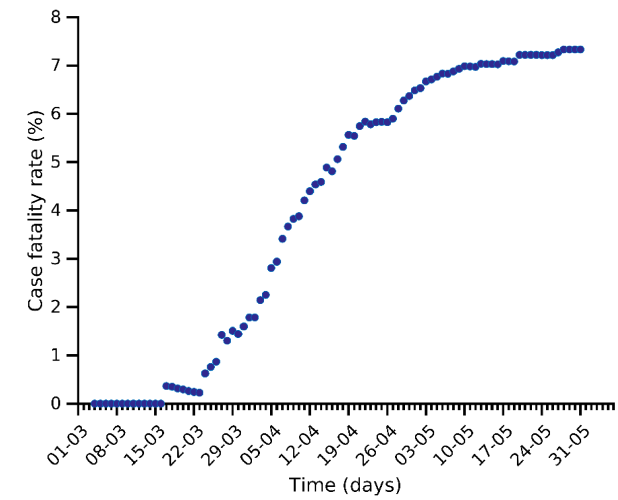




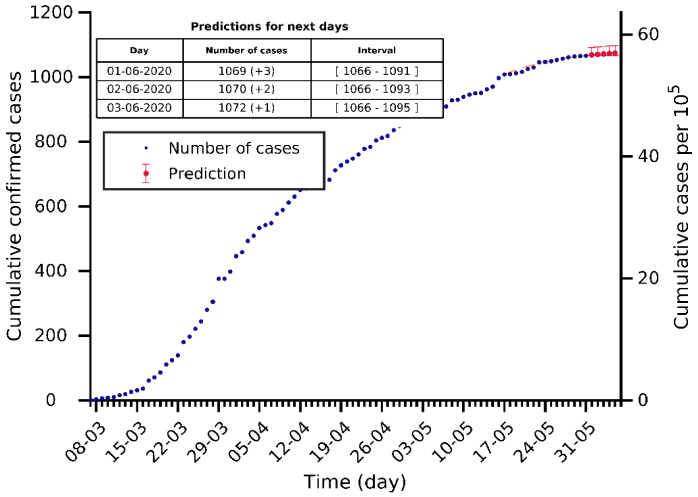


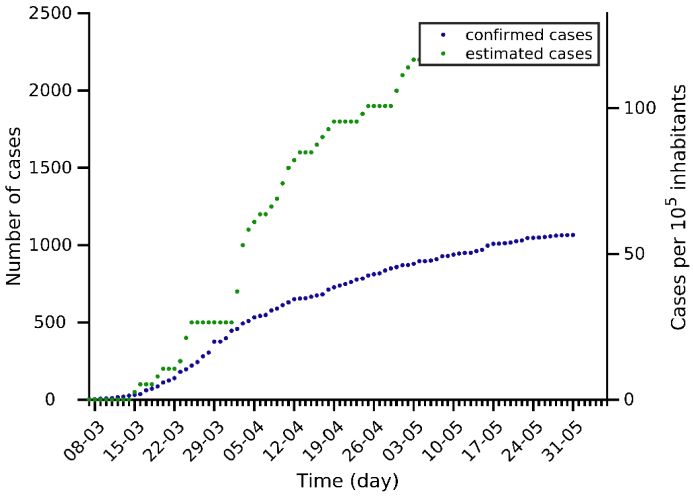


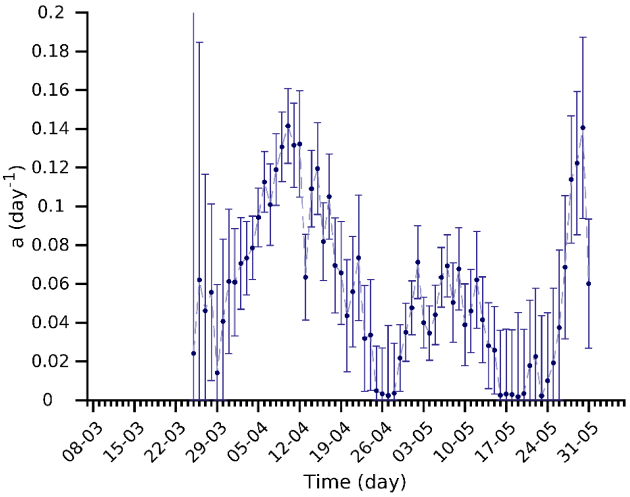


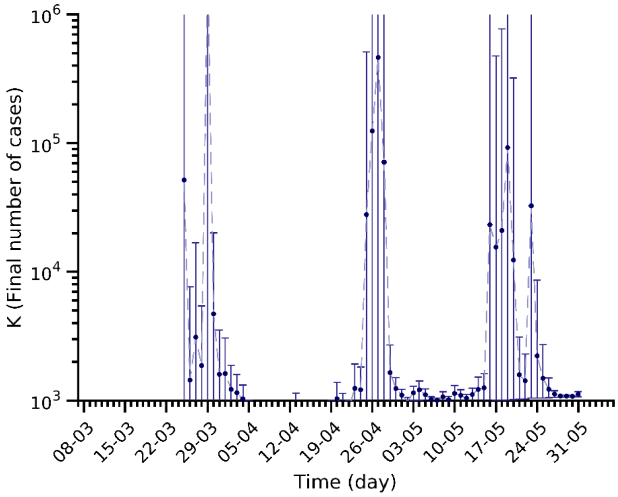


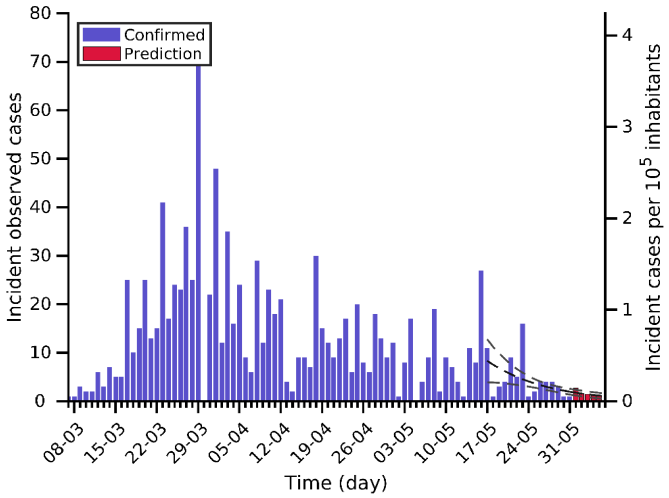
Latvia 31-05-2020. Population: 1.9M. Current cumulated incidence: $57/10^5$

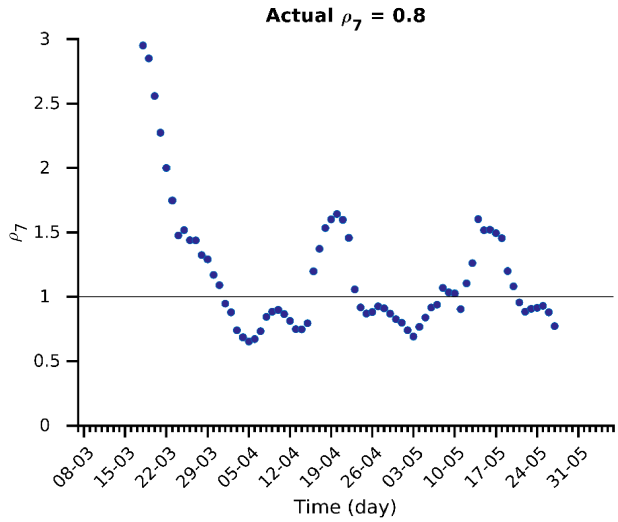


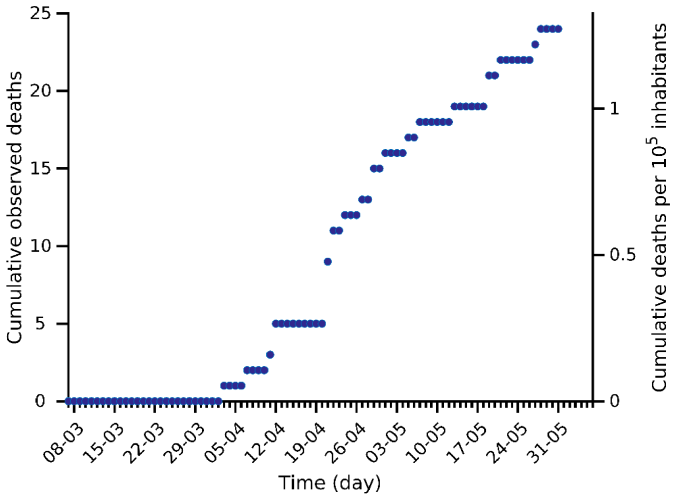


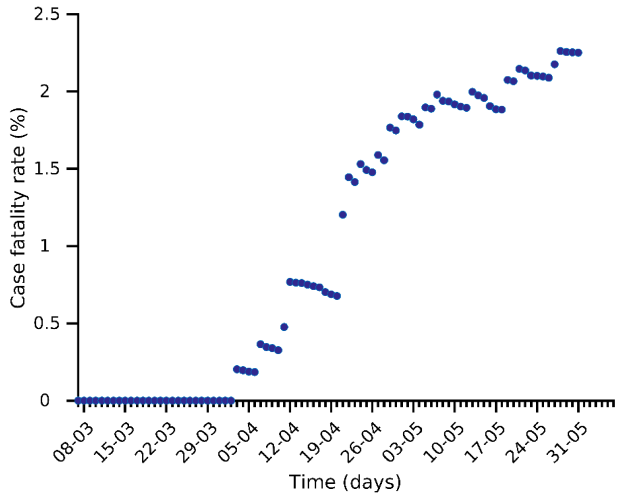




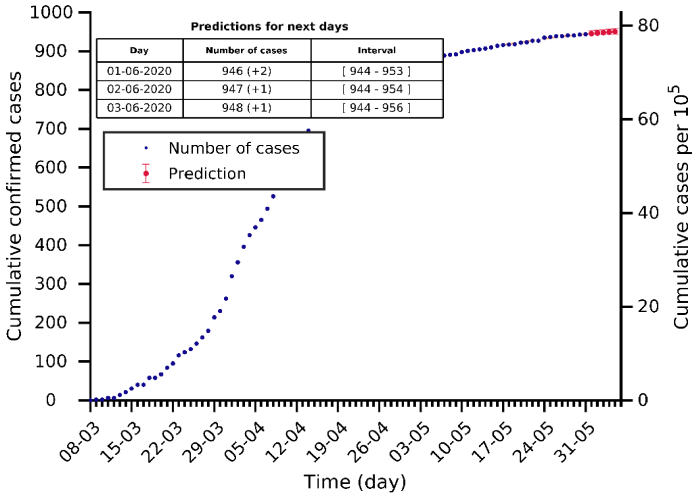


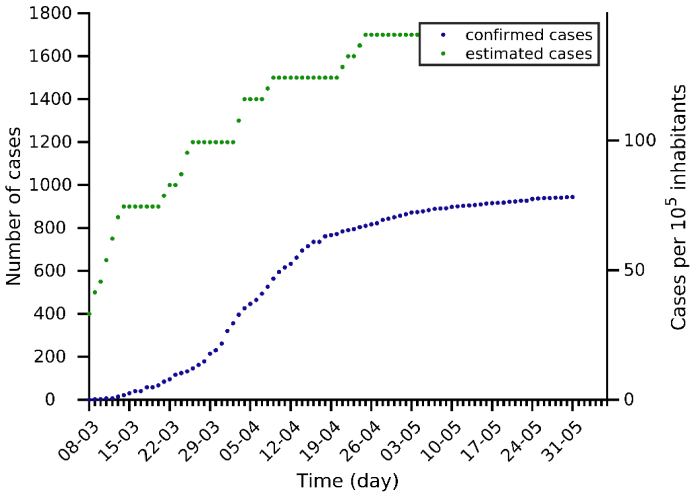


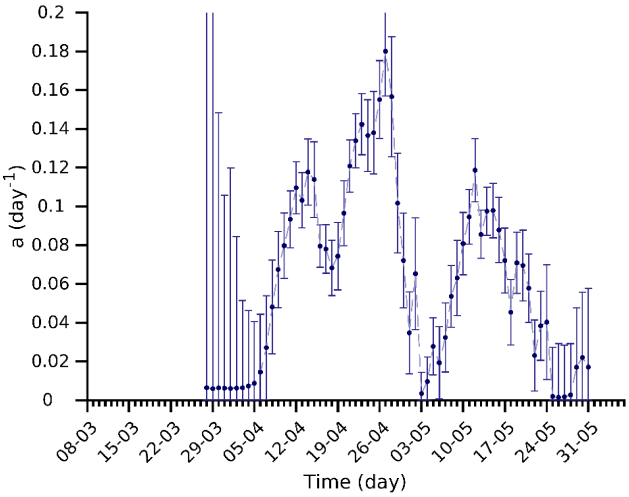


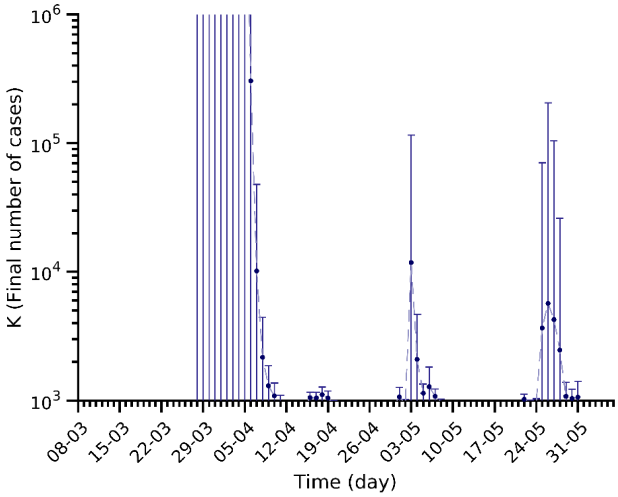


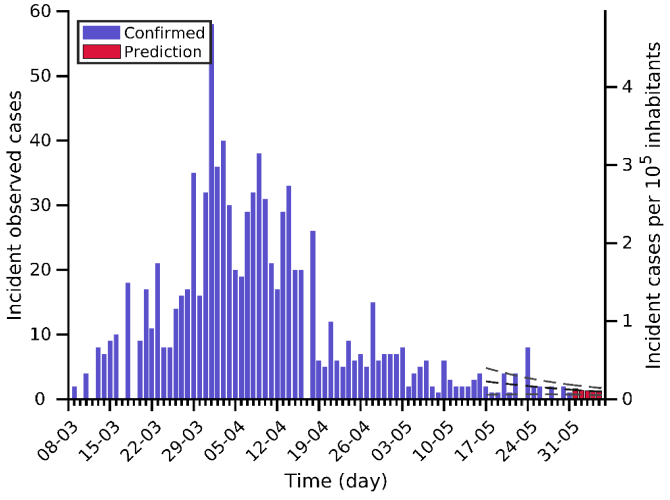
Cyprus 31-05-2020. Population: 1.2M. Current cumulated incidence: $78/10^5$

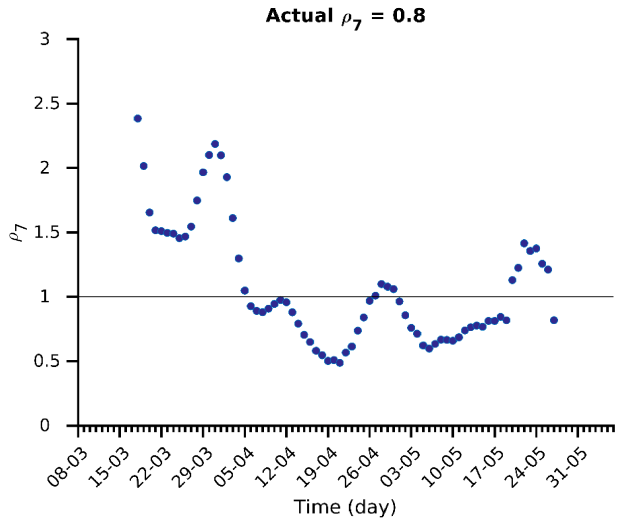


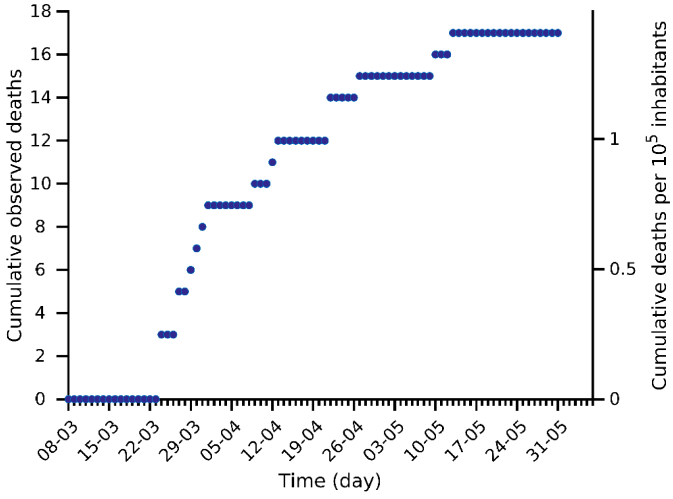


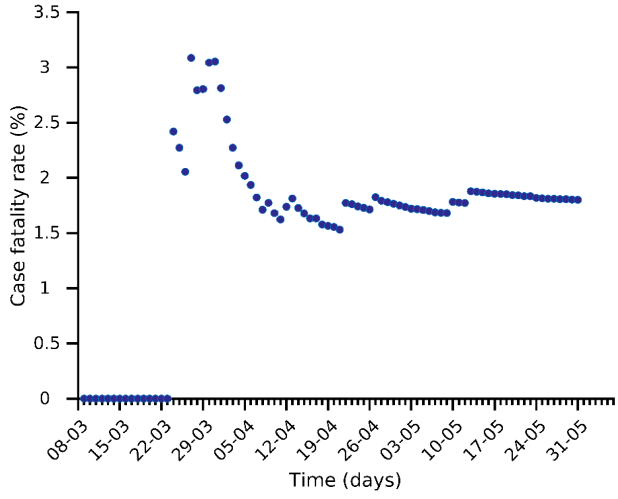




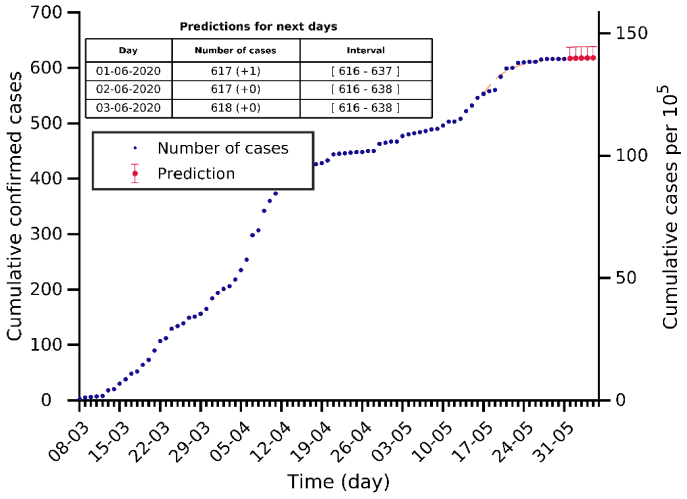


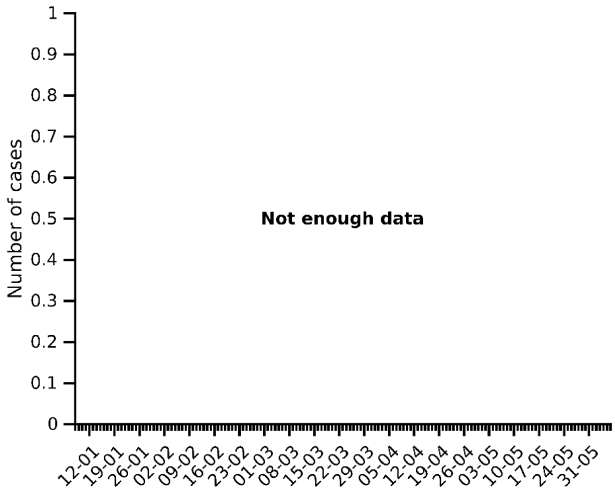


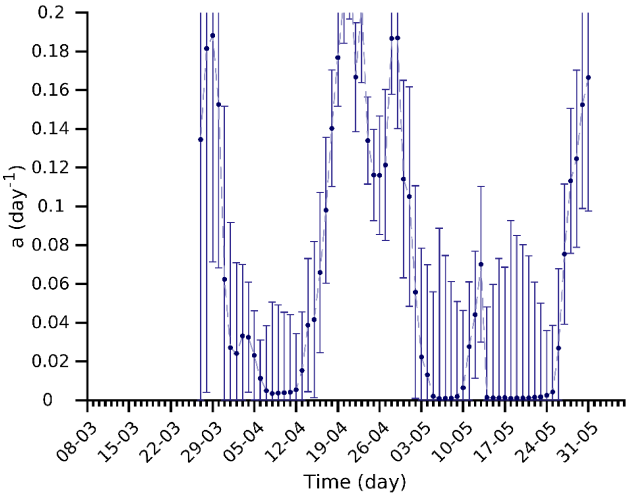


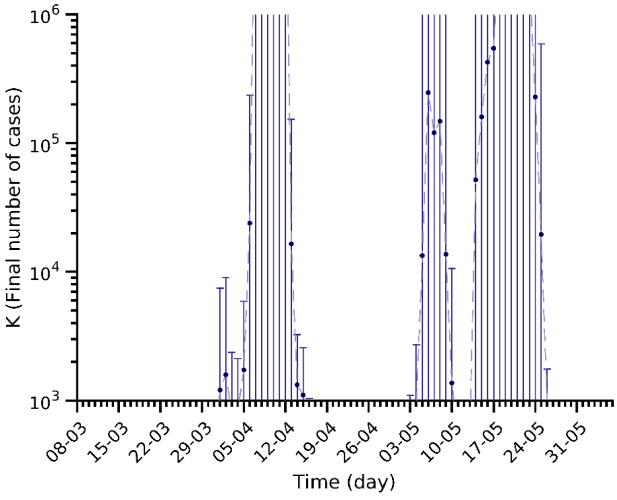


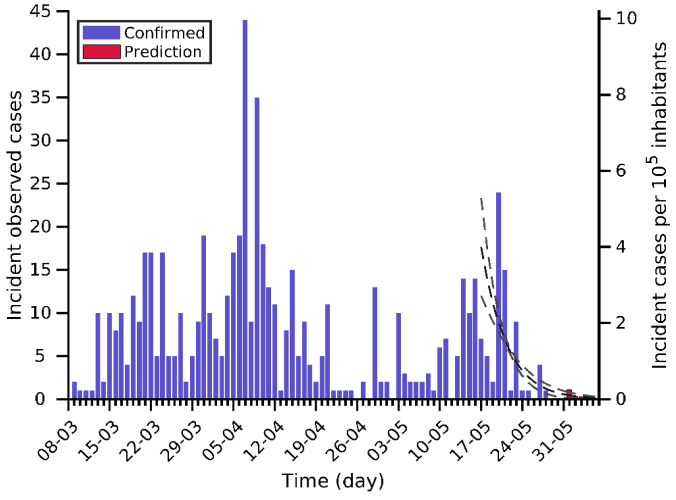
Malta 31-05-2020. Population: 0.4M. Current cumulated incidence: 140/10⁵

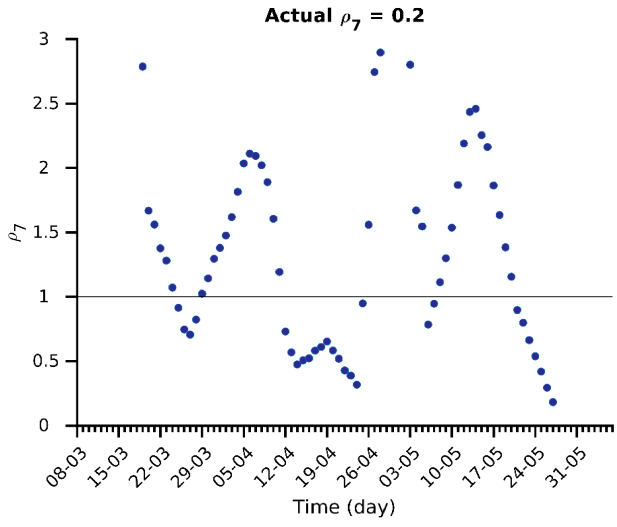


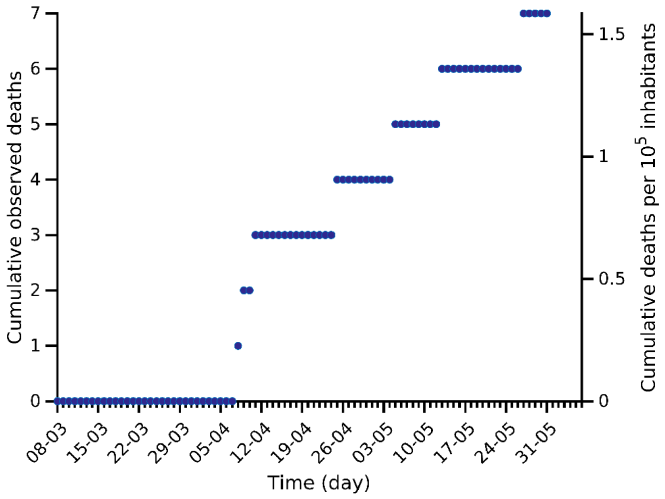


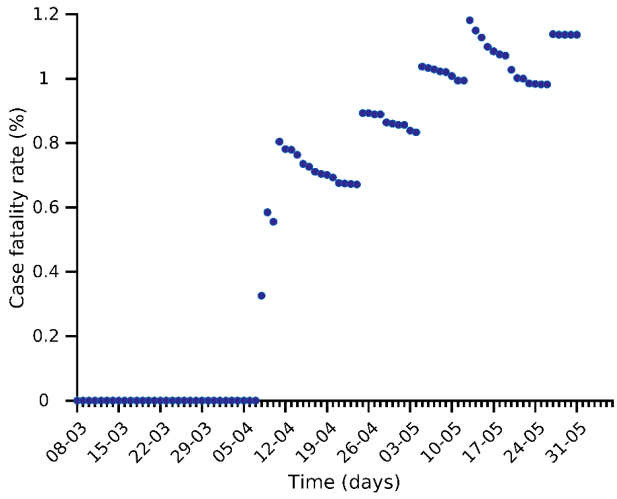








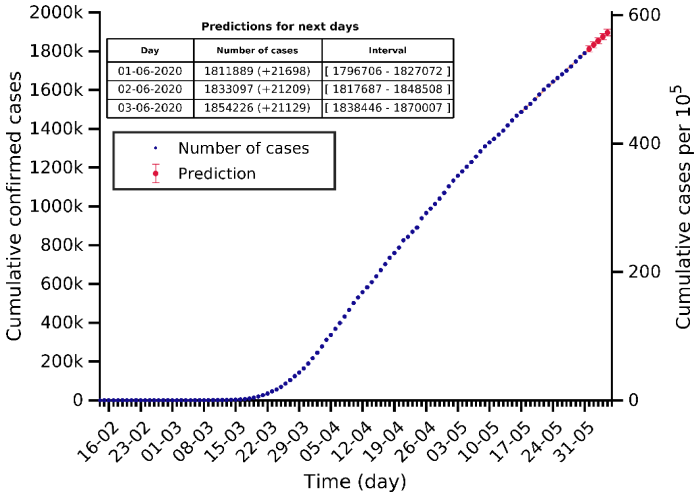


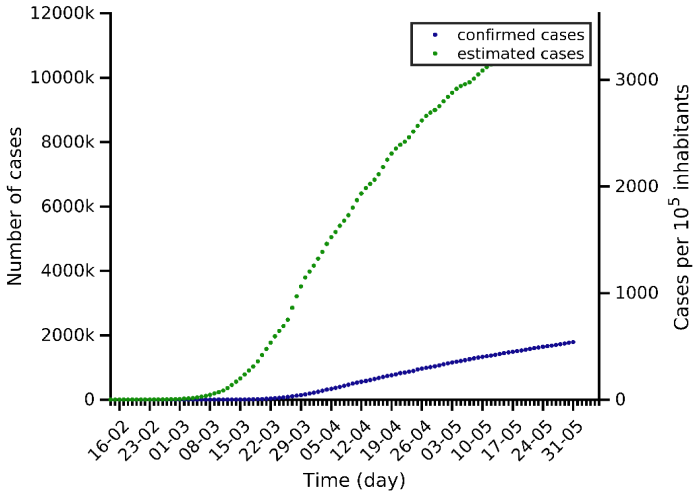


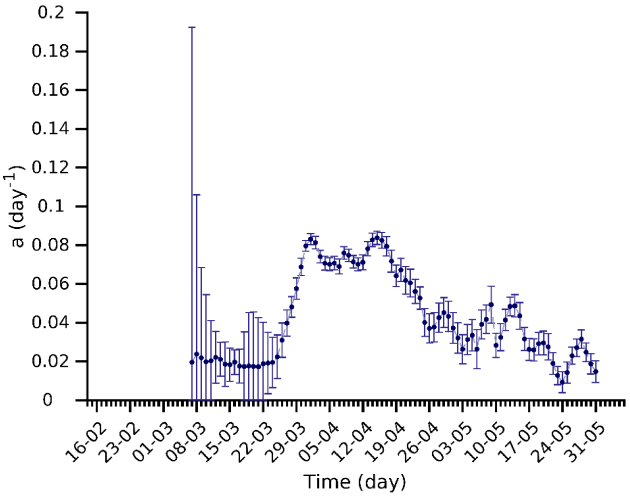
(2) Analysis and prediction of COVID-19 for other countries

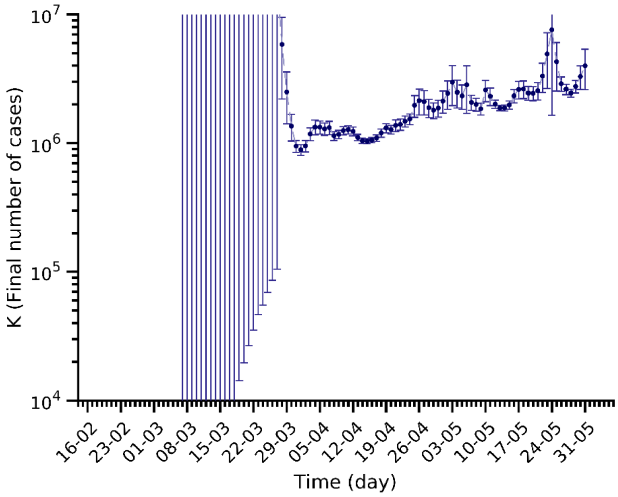
Data obtained from https://www.ecdc.europa.eu/en/geographical-distribution-2019-ncov-cases

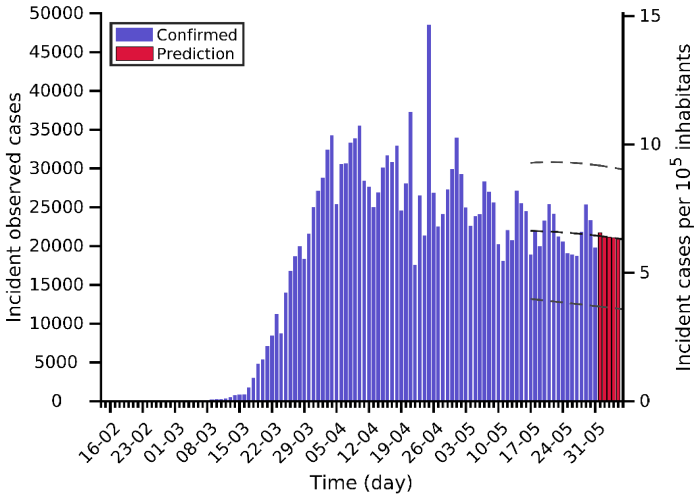
USA 31-05-2020. Population: 331.0M. Current cumulated incidence: 541/10^5

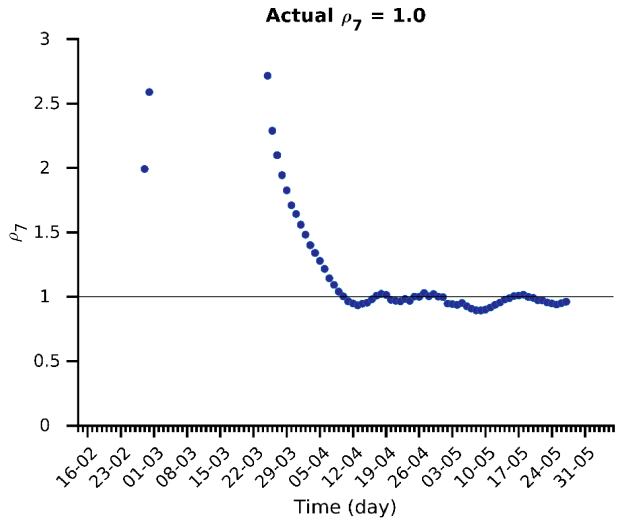


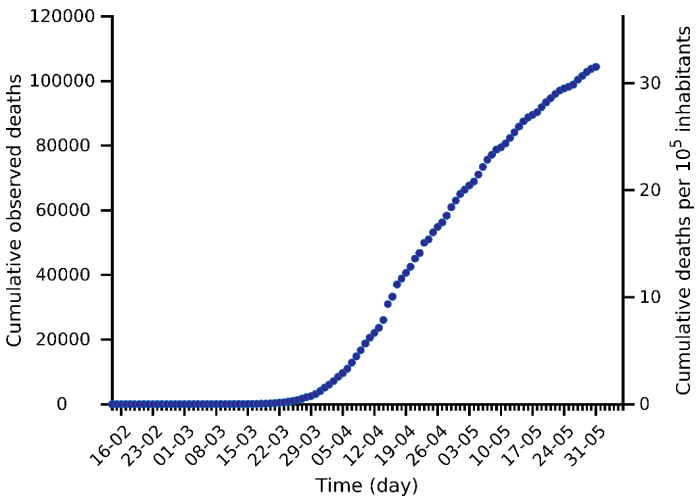


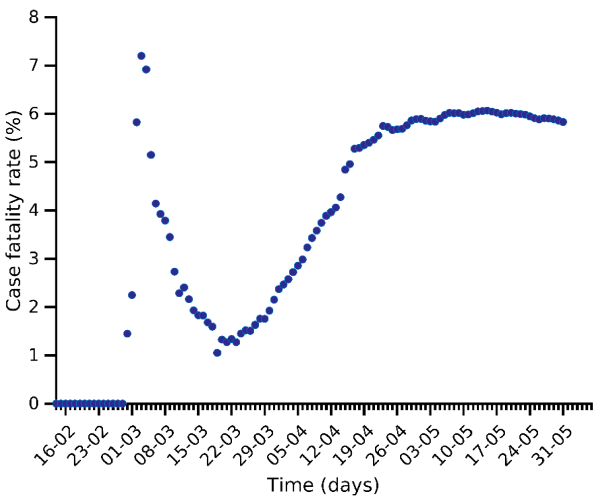




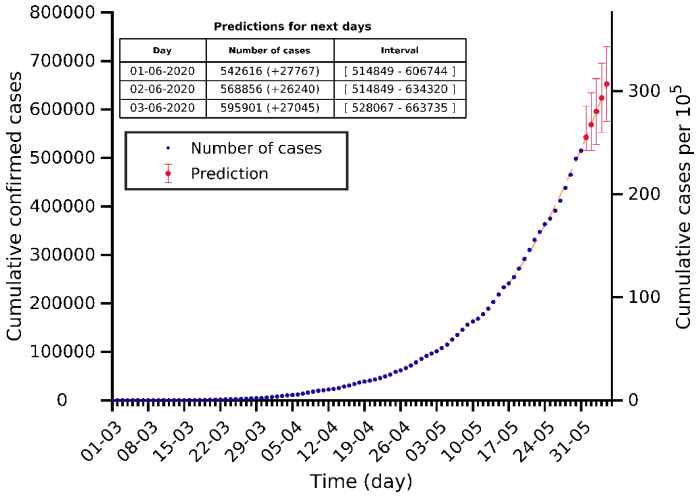


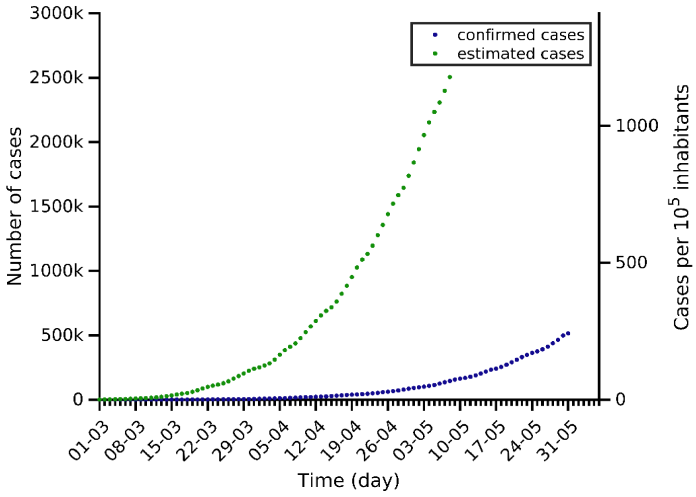


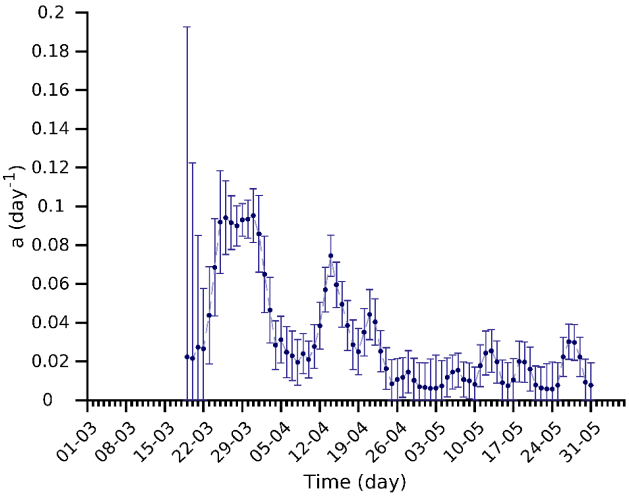


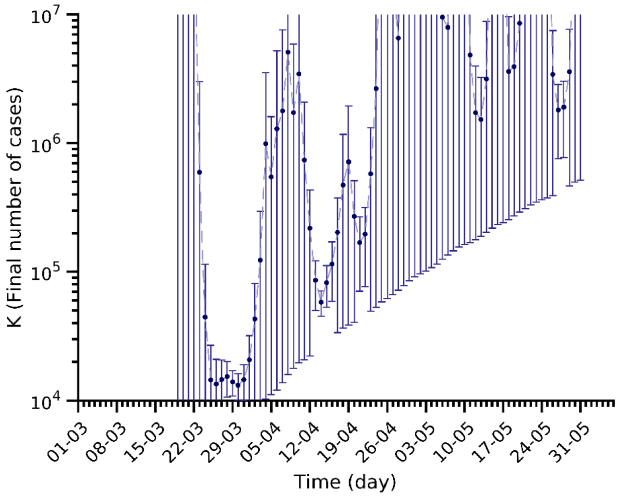


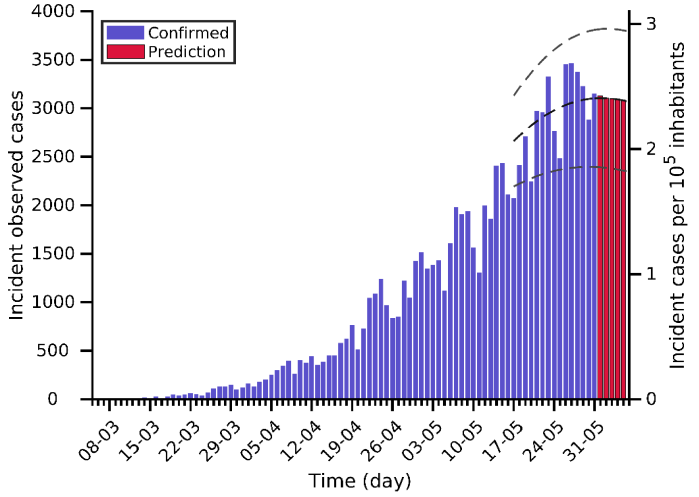
Brazil 31-05-2020. Population: 212.6M. Current cumulated incidence: 242/10^5

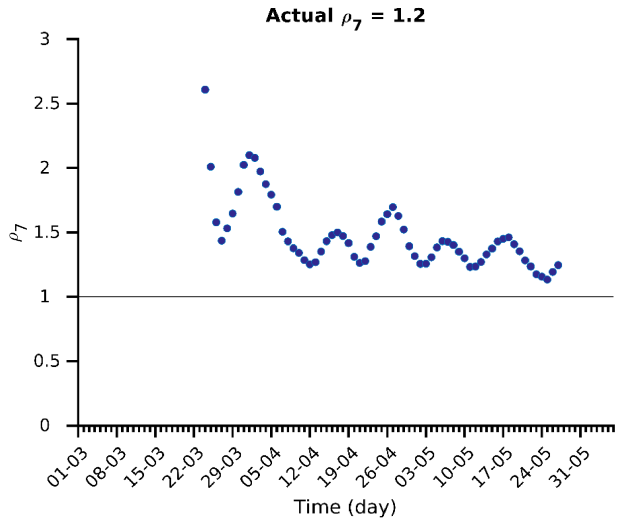


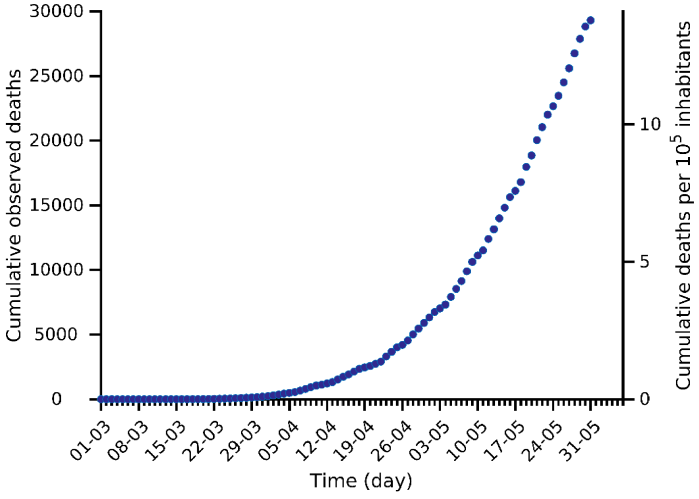


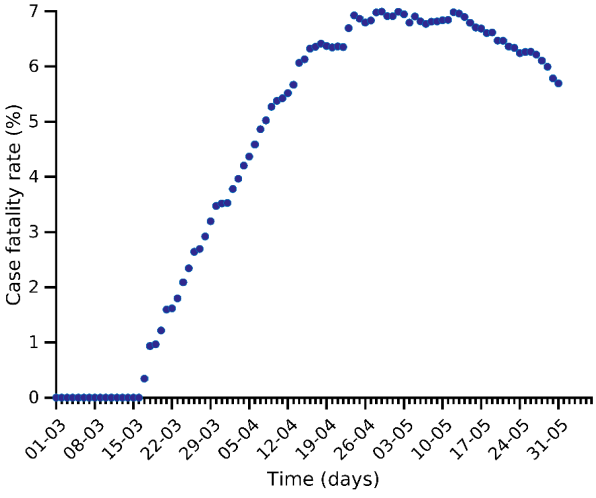




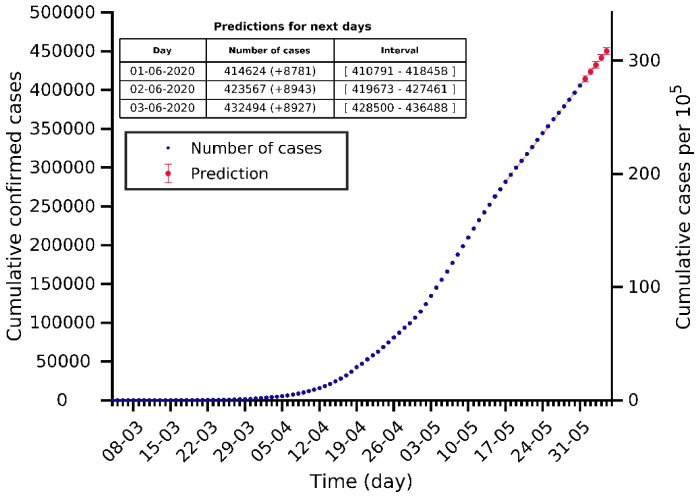


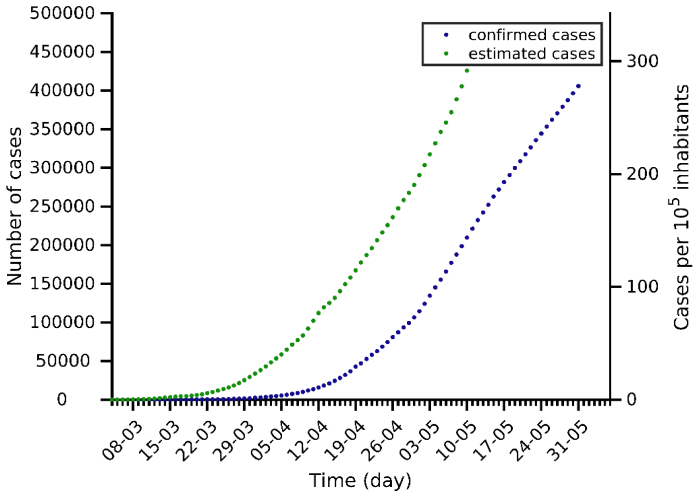


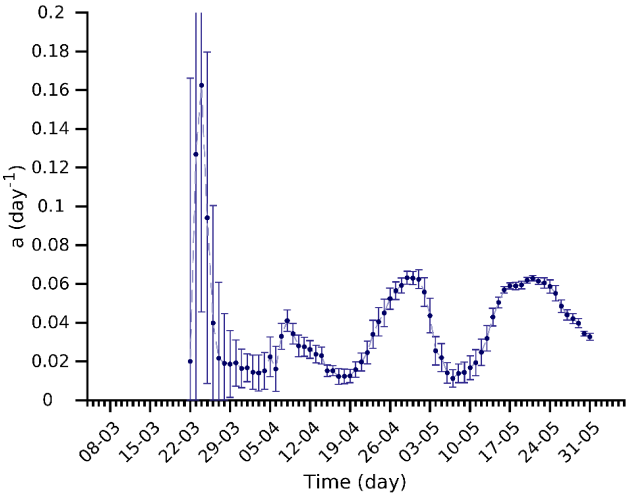


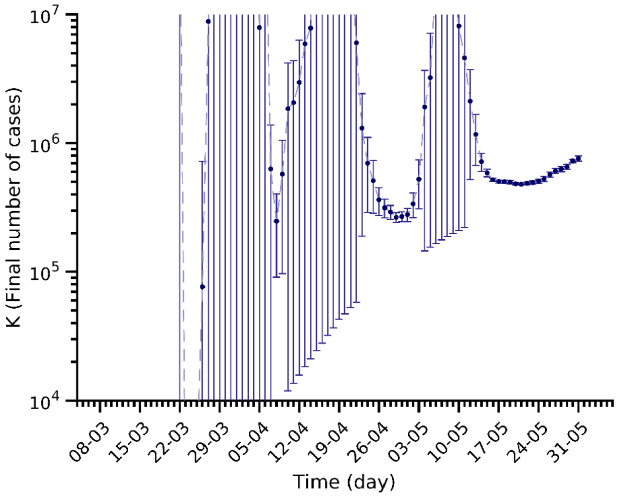


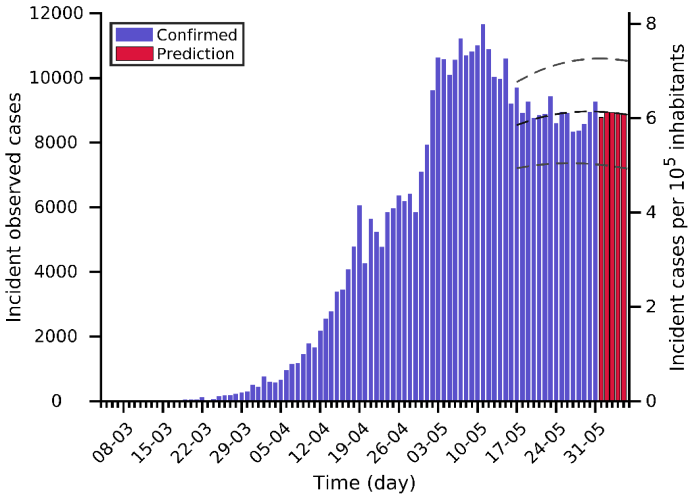
Russia 31-05-2020. Population: 145.9M. Current cumulated incidence: $278/10^5$

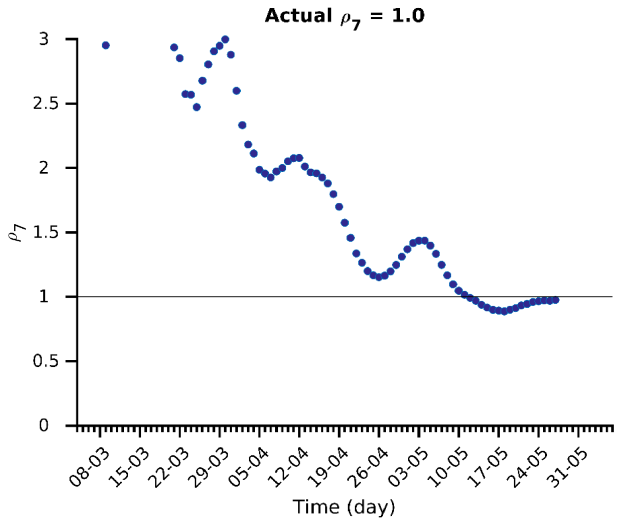


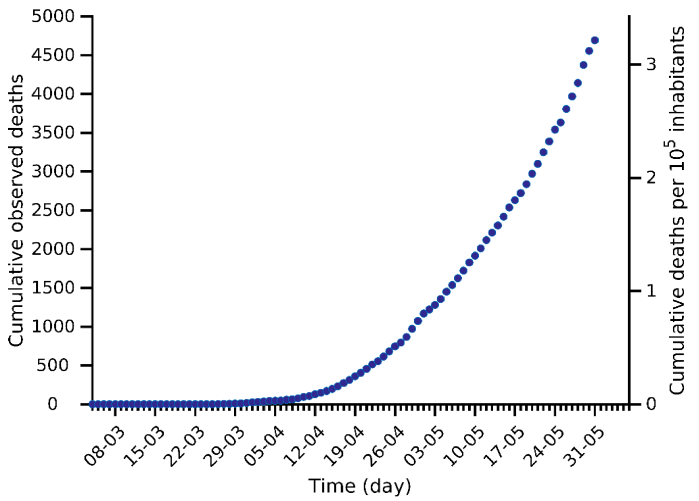


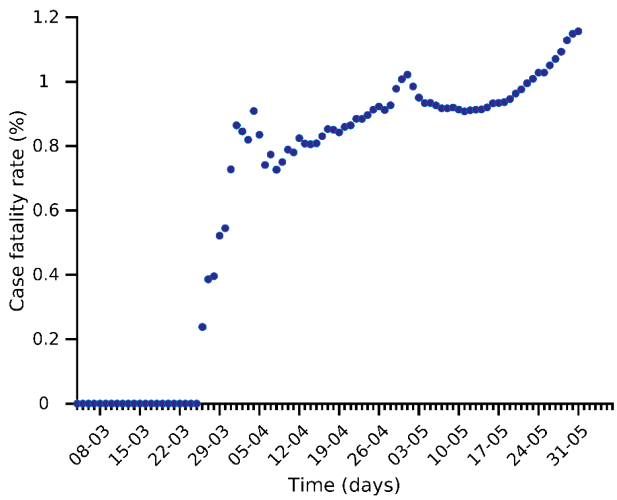




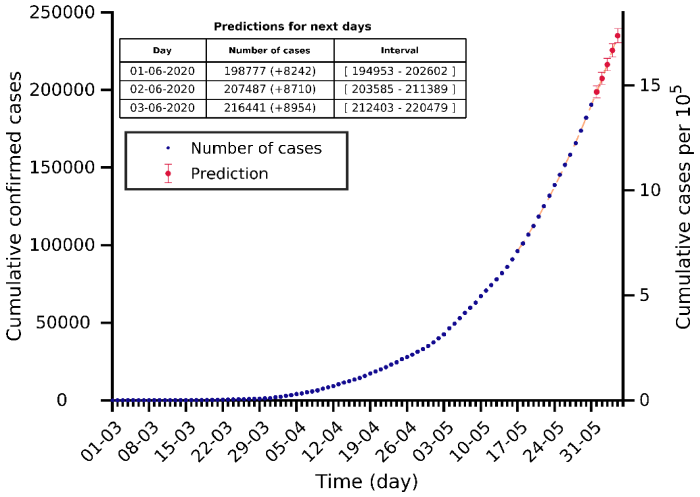


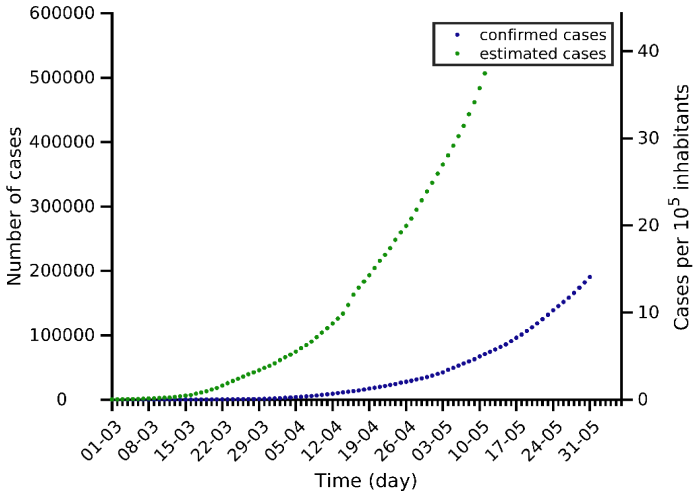


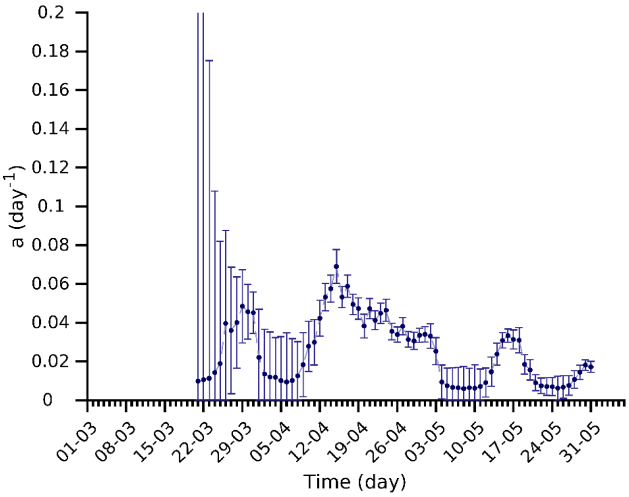


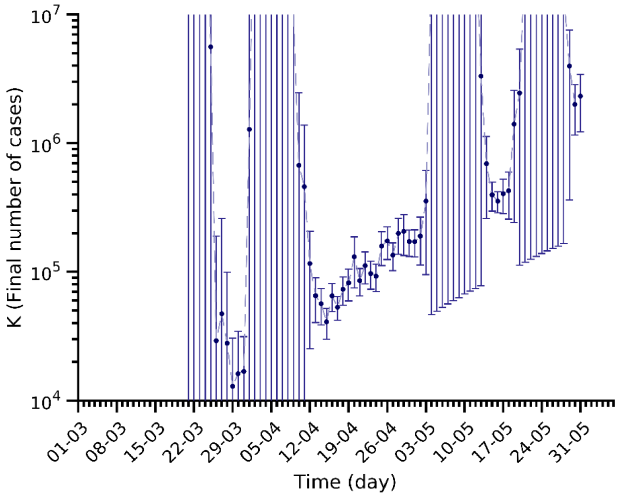


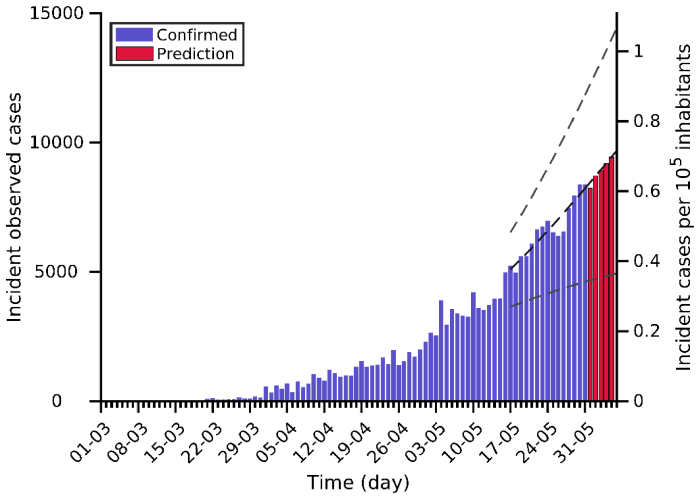
India 31-05-2020. Population: 1353.0M. Current cumulated incidence: $14/10^5$

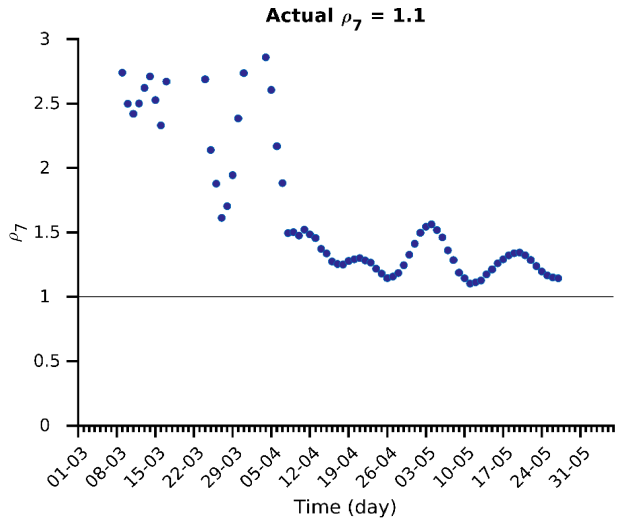


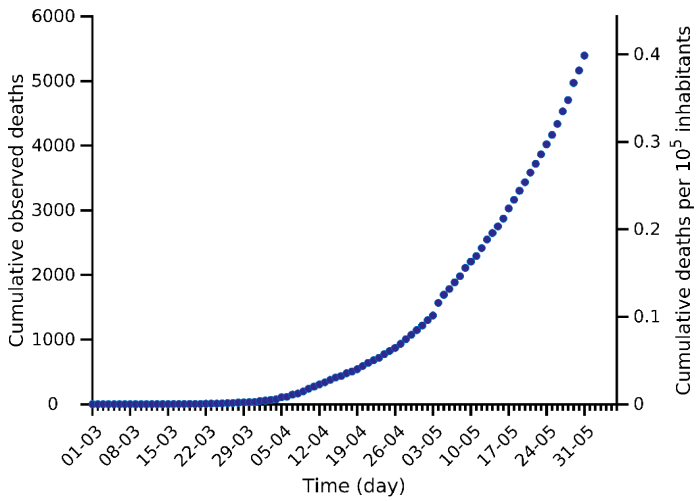


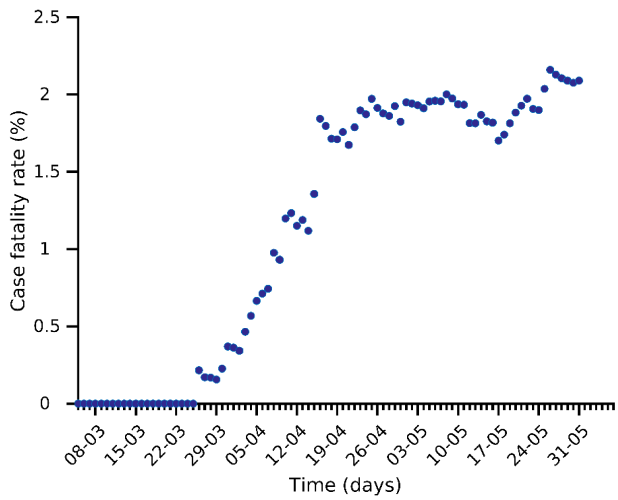




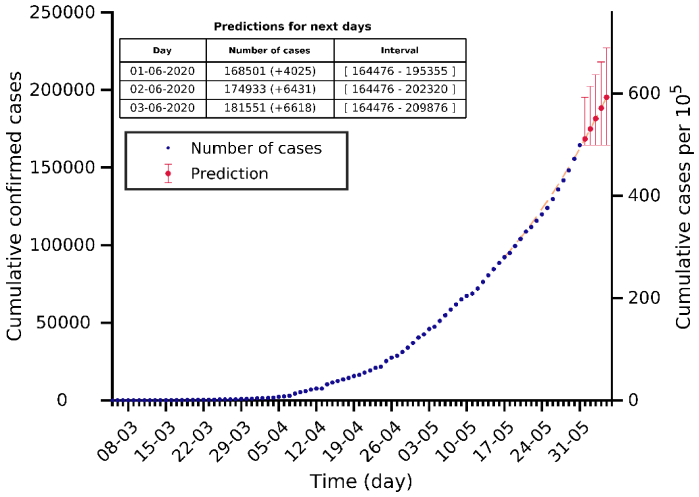


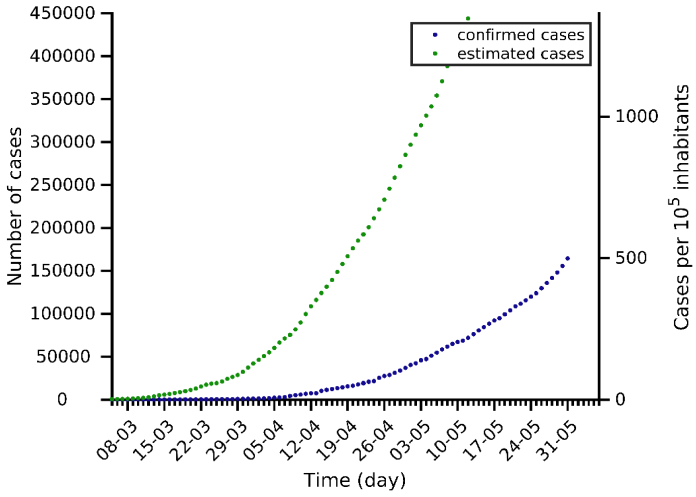


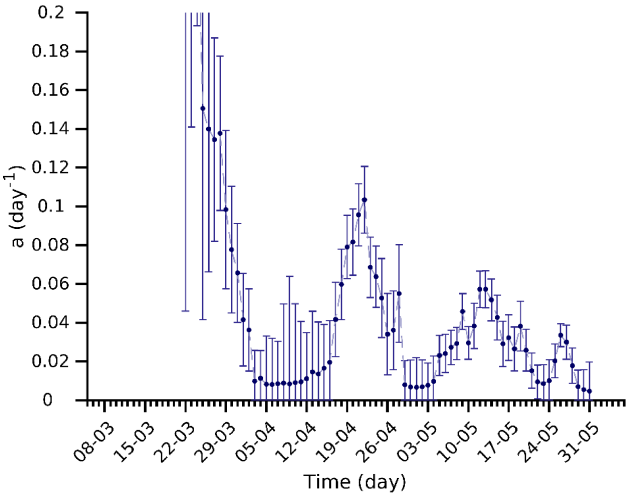


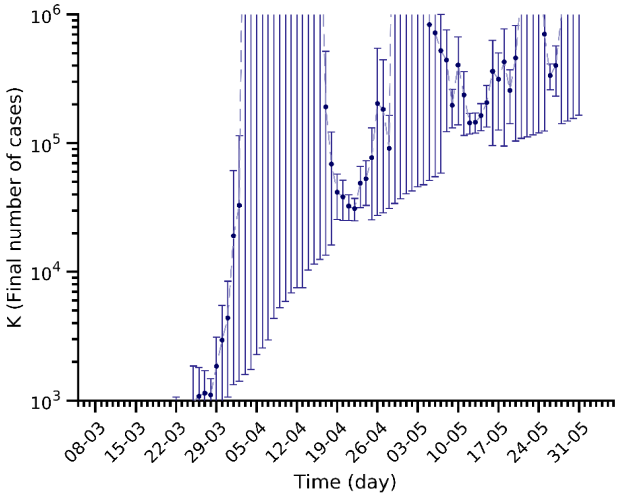


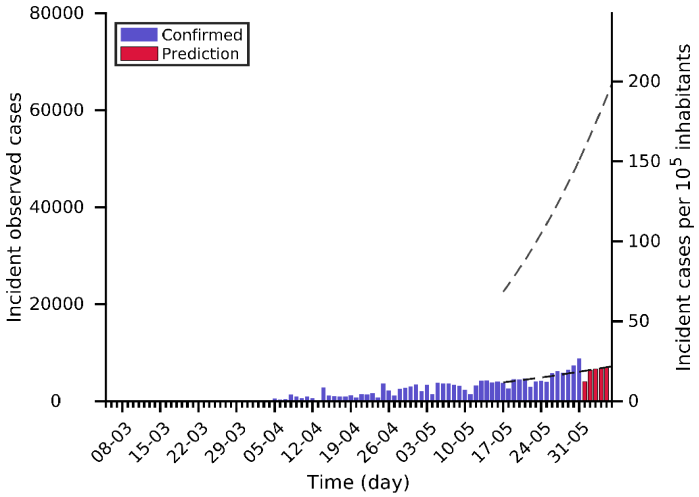
Peru 31-05-2020. Population: 33.0M. Current cumulated incidence: 499/10^5

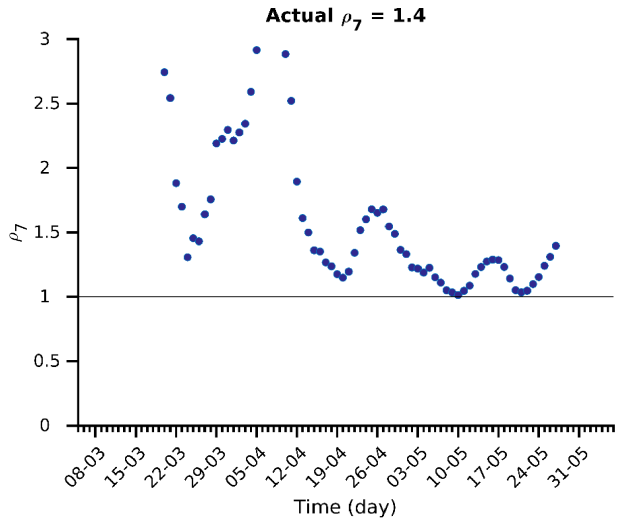


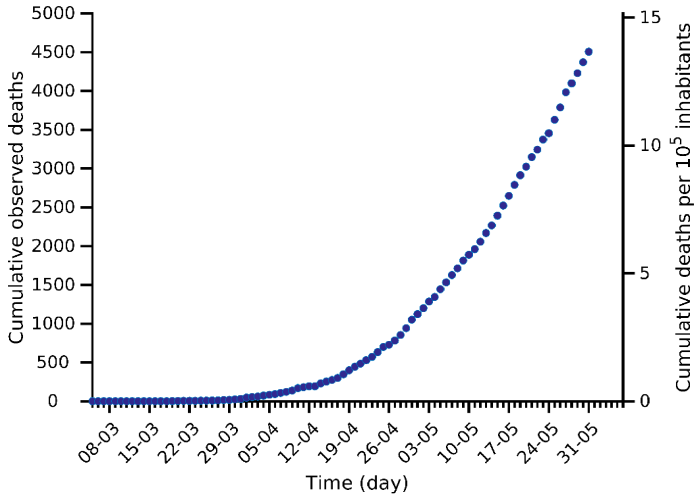


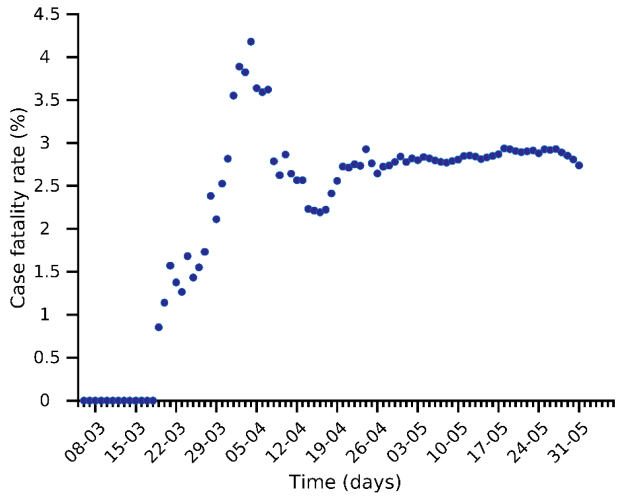




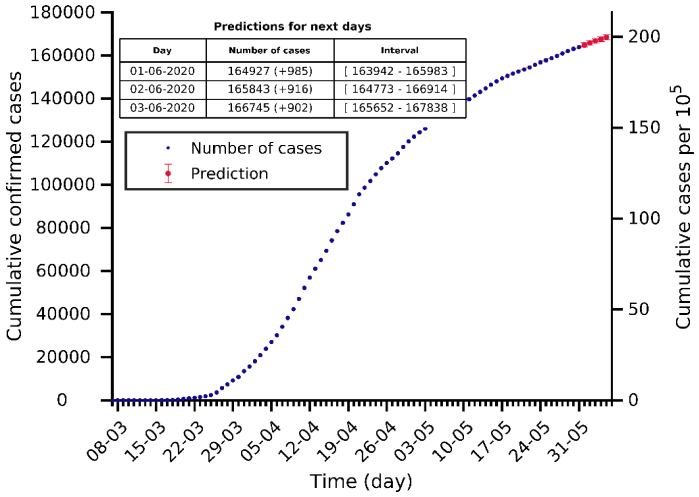


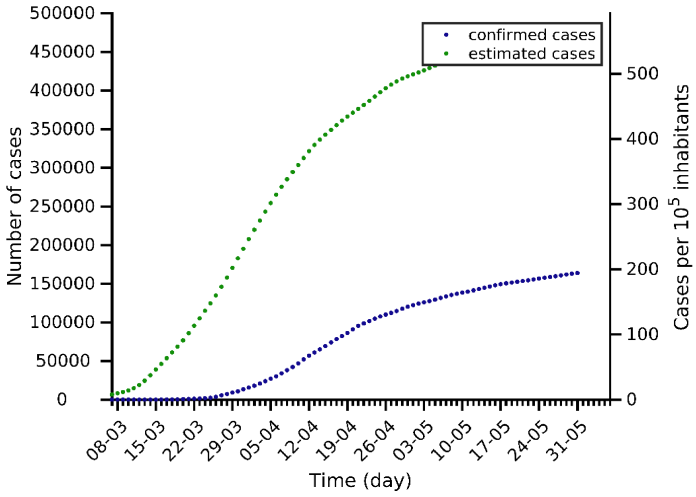


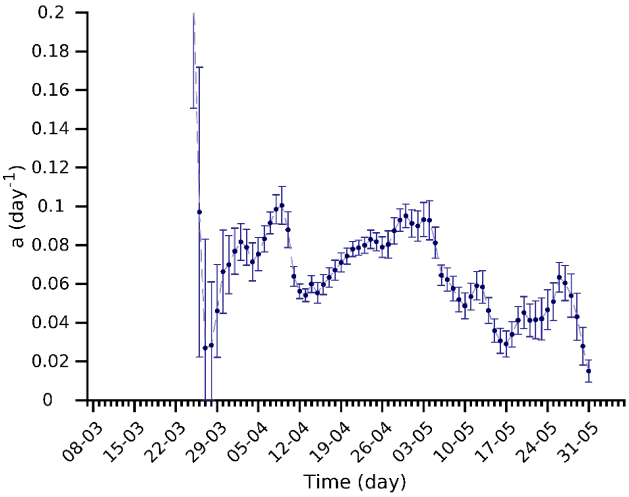


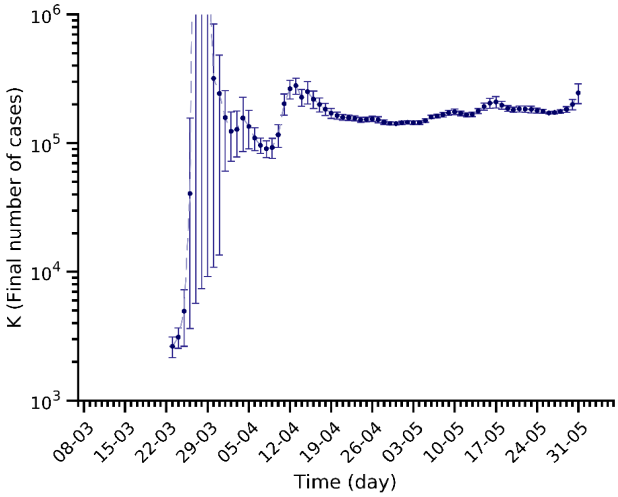


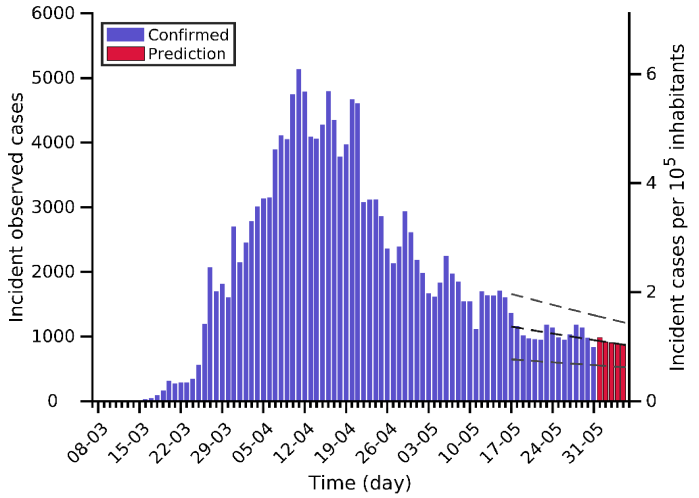
Turkey 31-05-2020. Population: 84.3M. Current cumulated incidence: 194/10^5

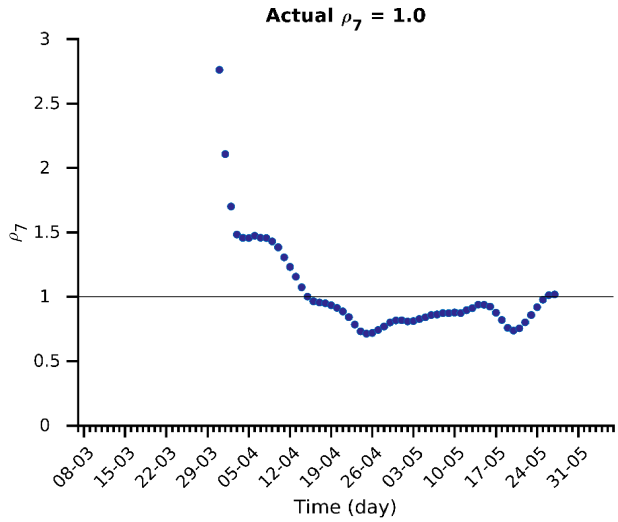


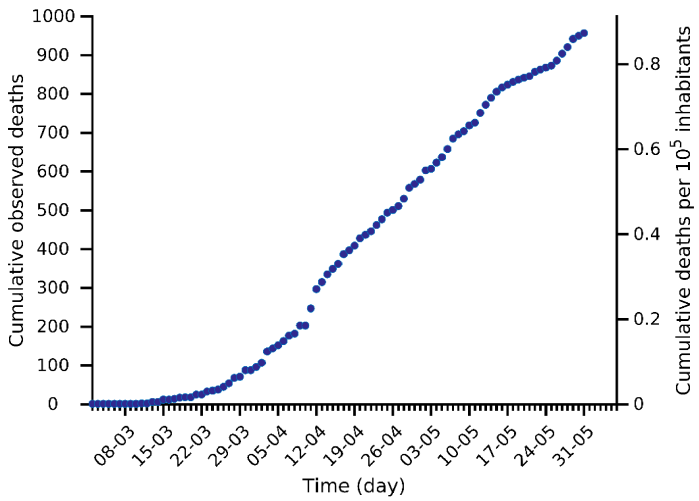


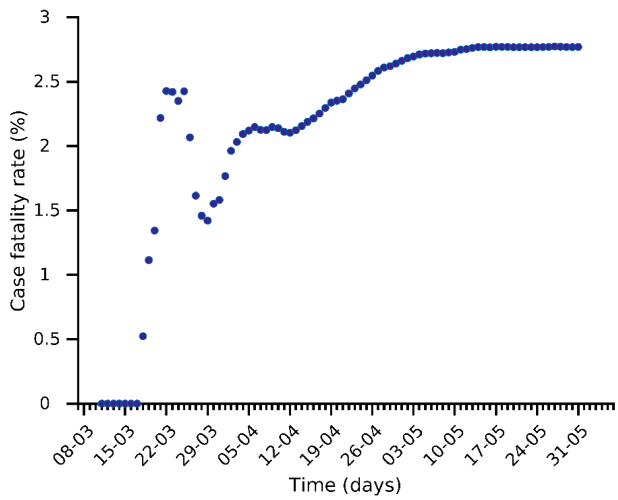




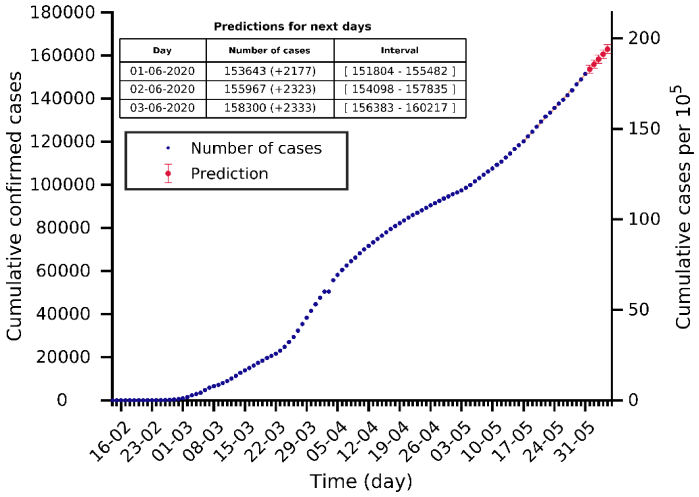


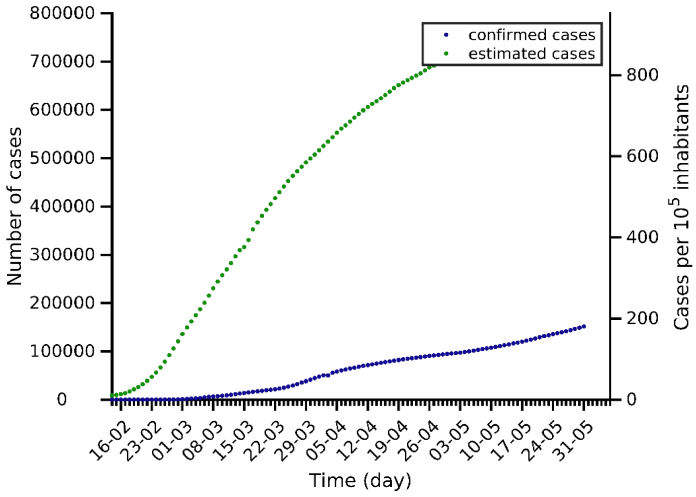


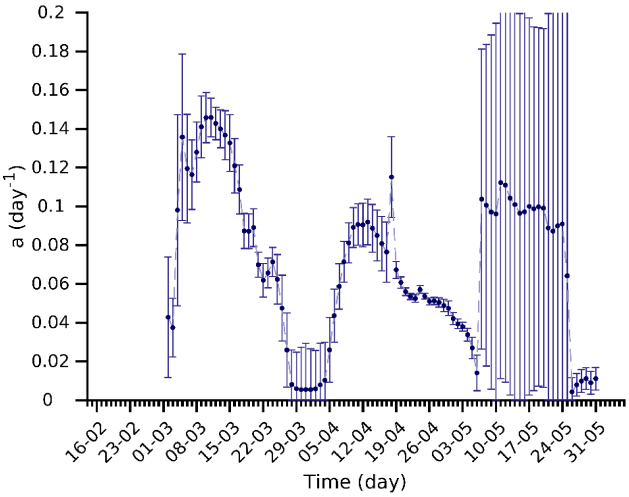


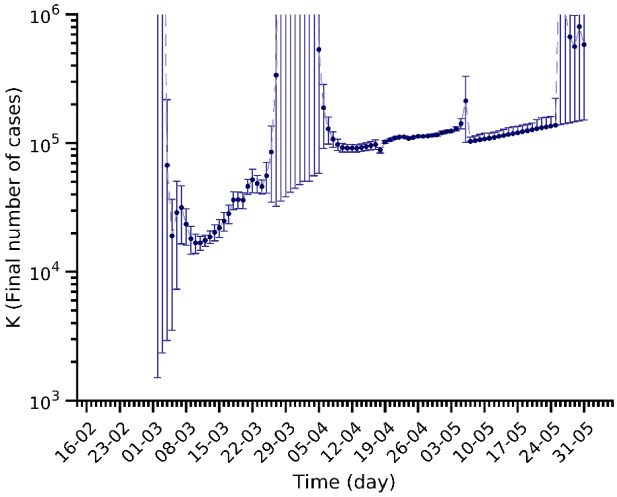


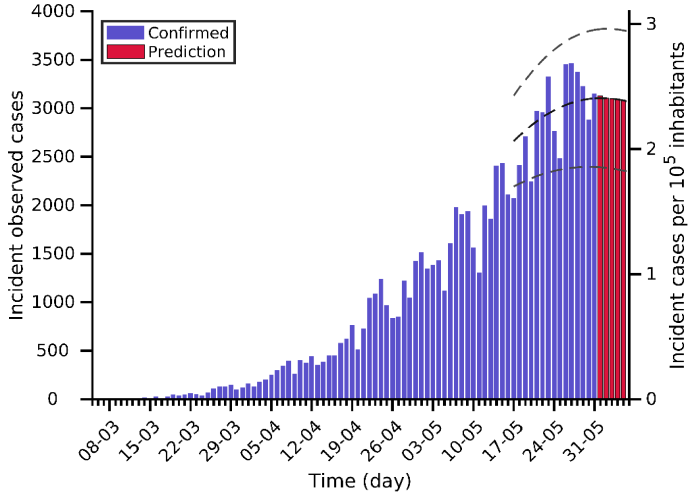
Iran 31-05-2020. Population: 84.0M. Current cumulated incidence: 180/10^5

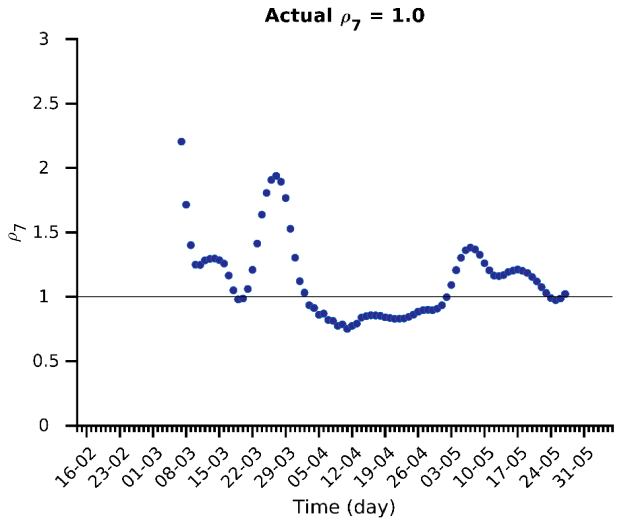


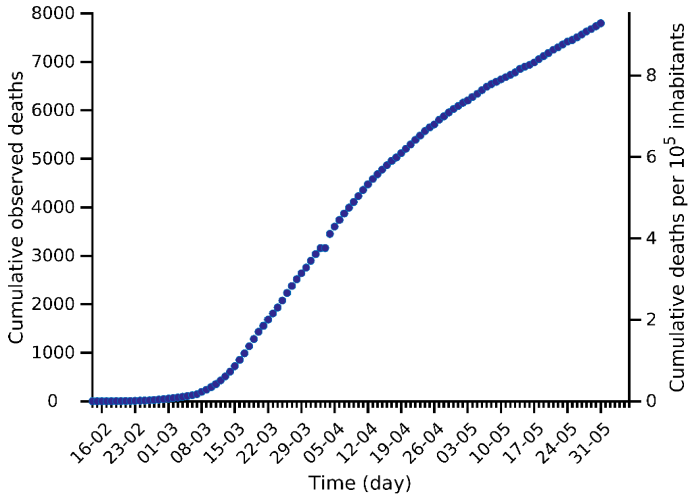


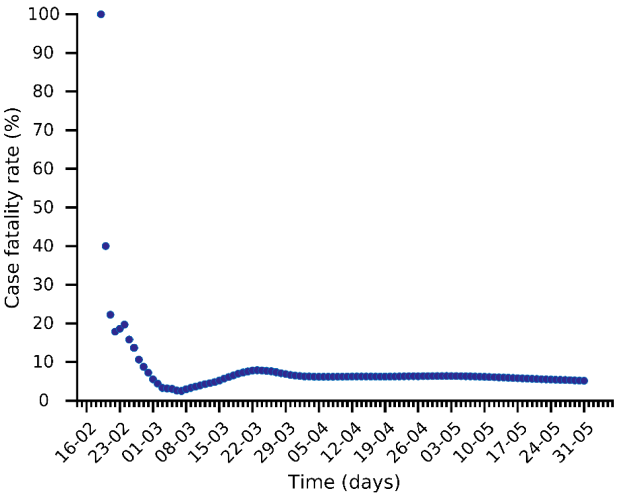




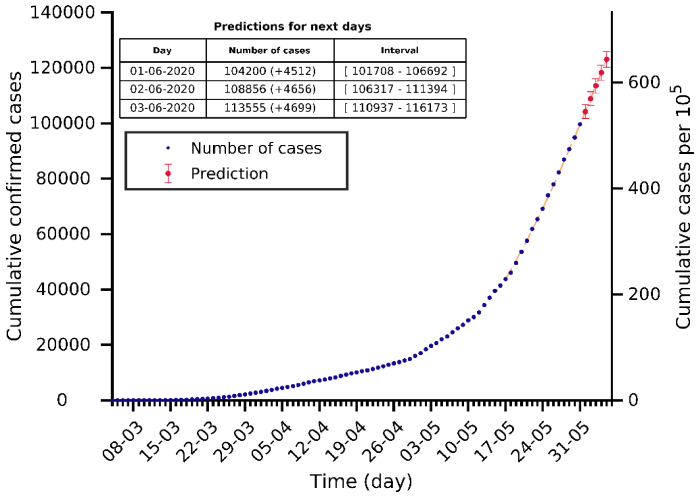


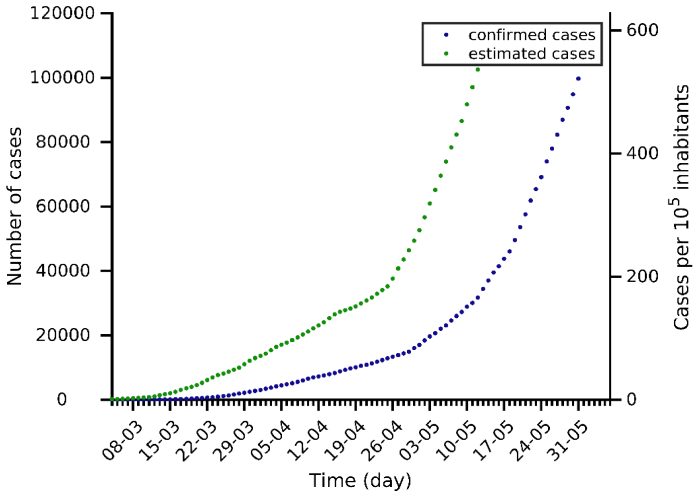


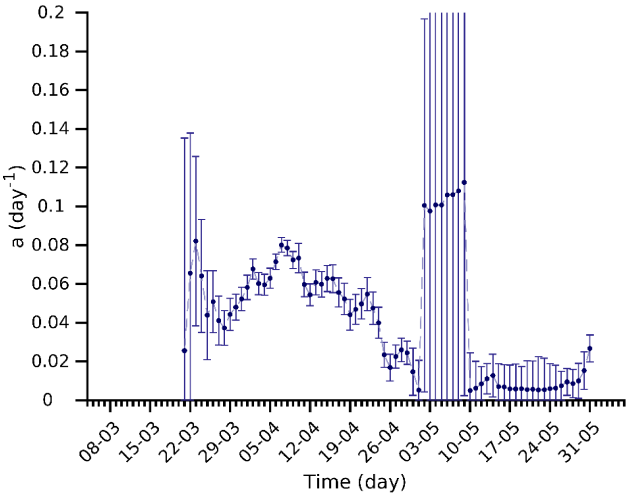


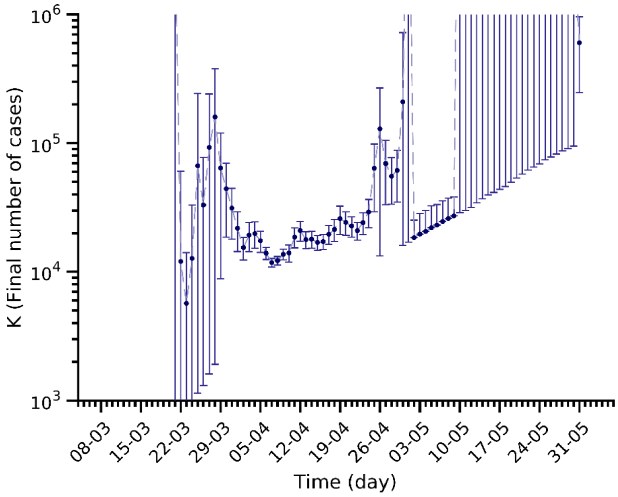


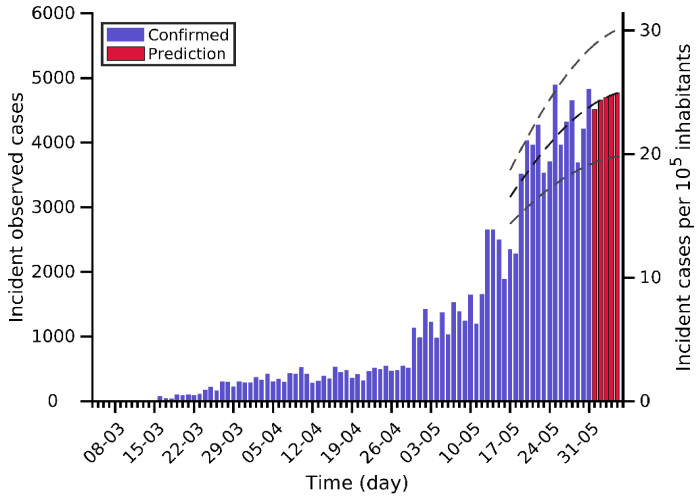
Chile 31-05-2020. Population: 19.1M. Current cumulated incidence: 521/10^5

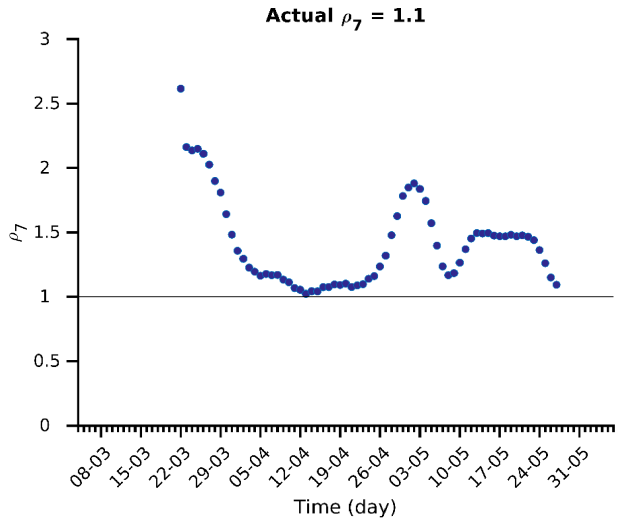


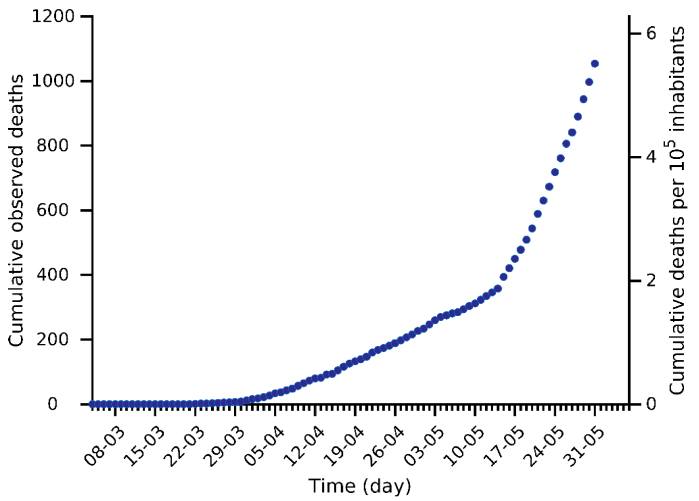


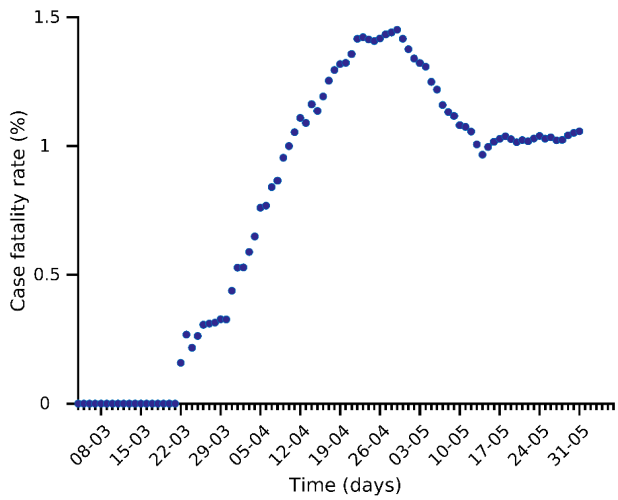




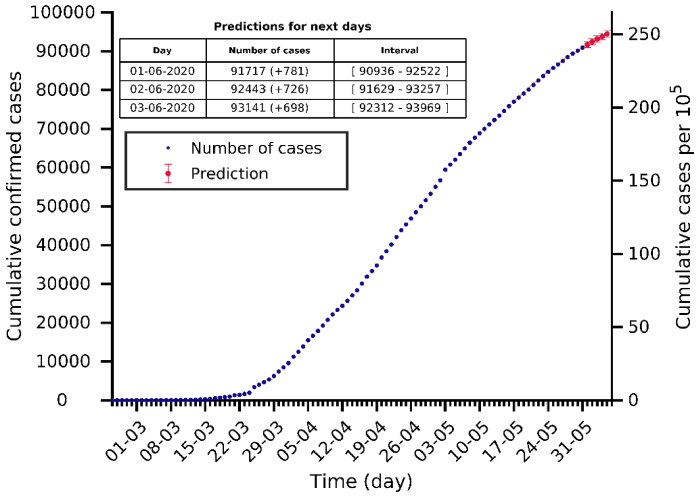


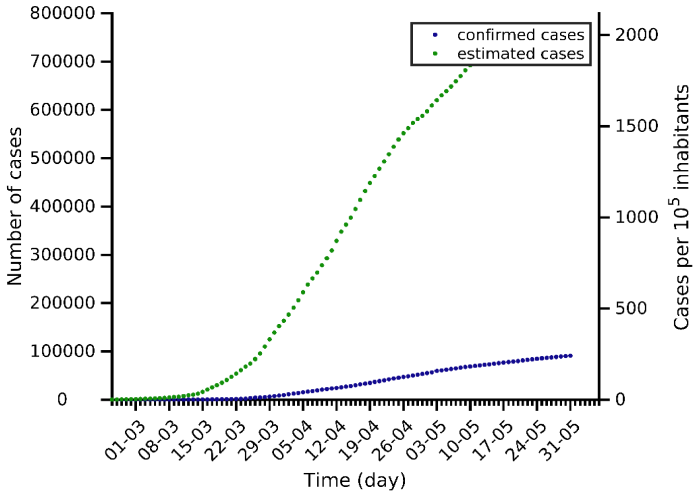


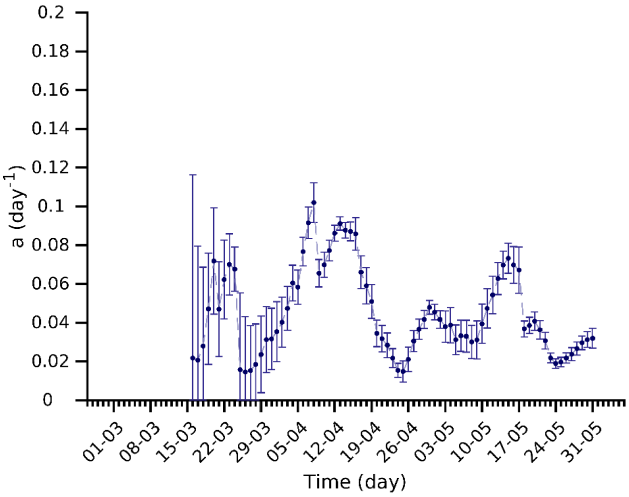


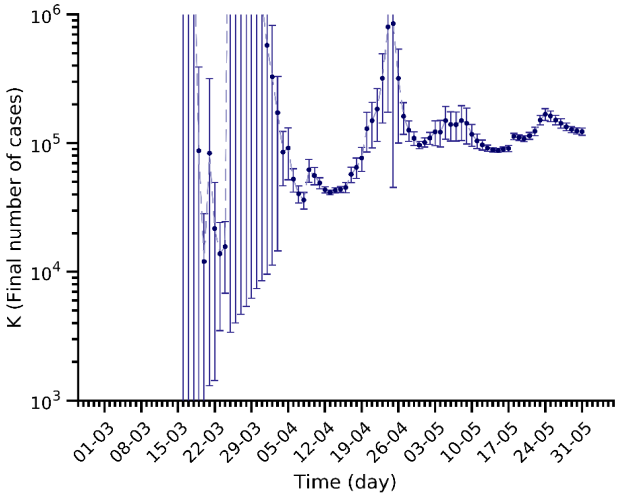


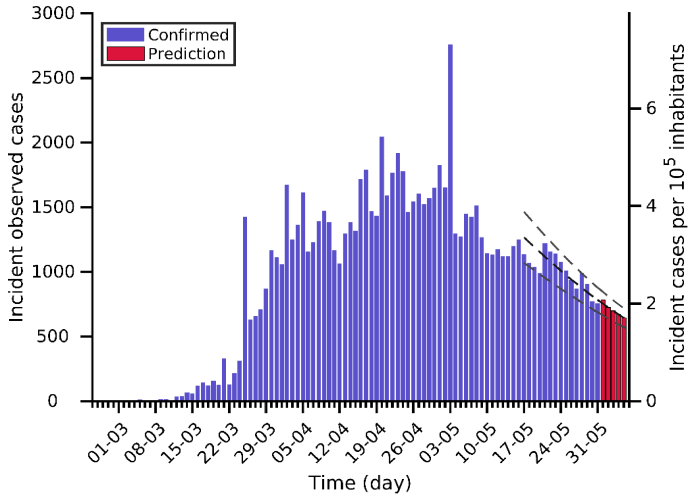
Canada 31-05-2020. Population: 37.7M. Current cumulated incidence: 241/10^5

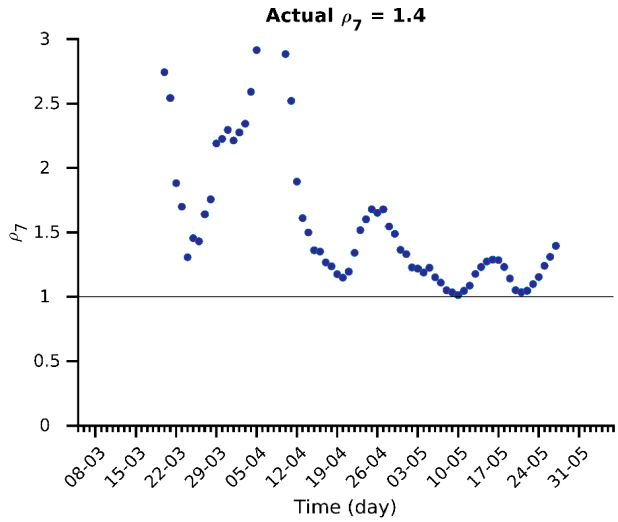


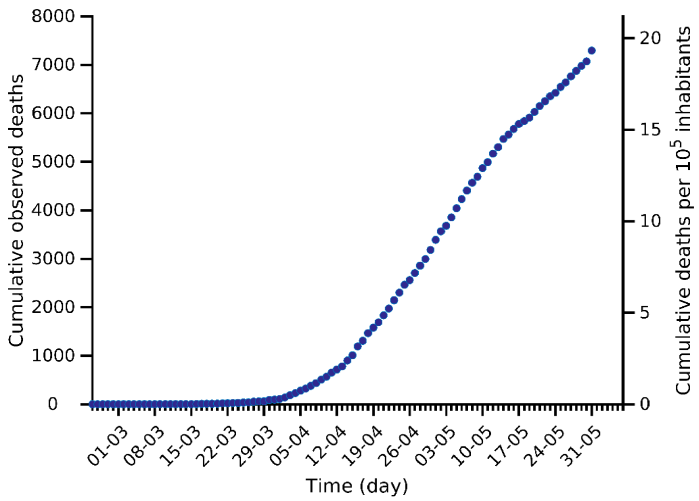


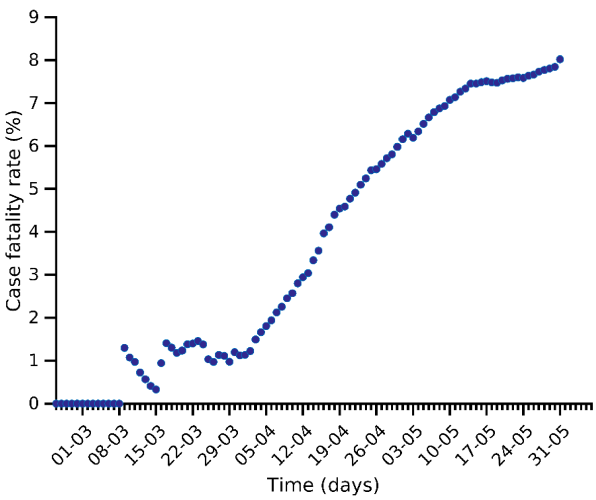




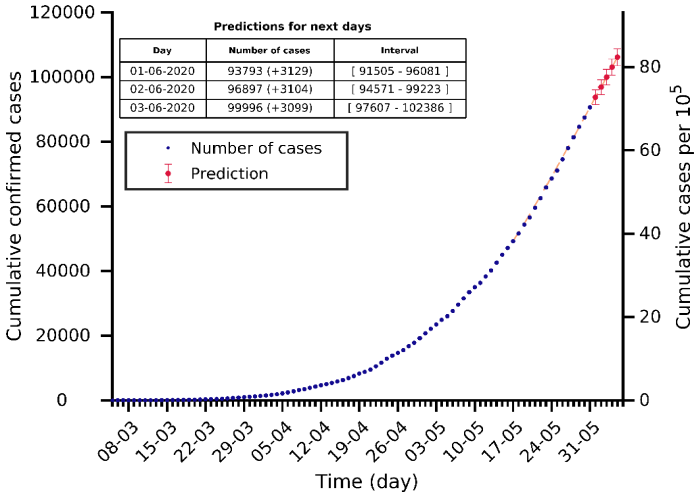


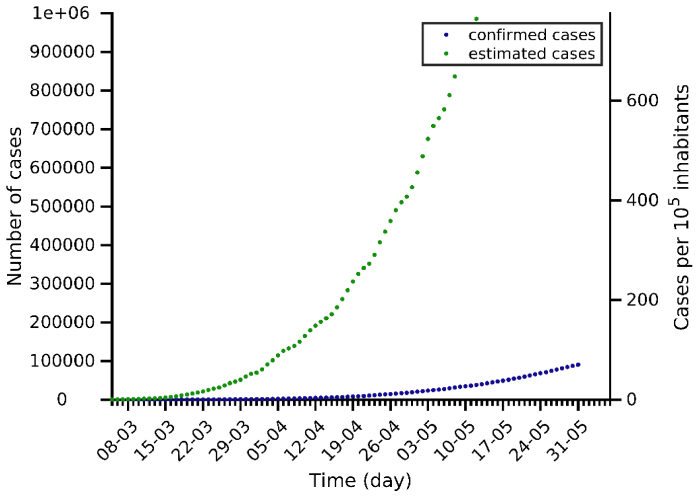


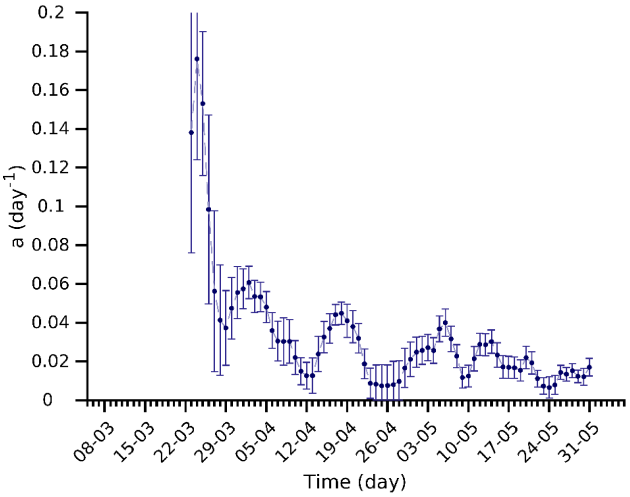


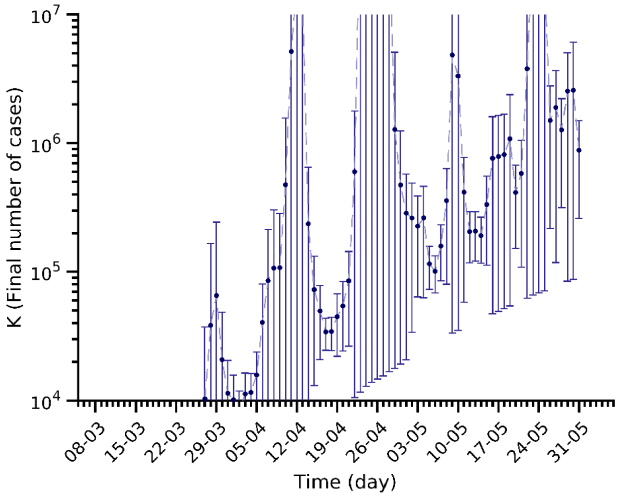


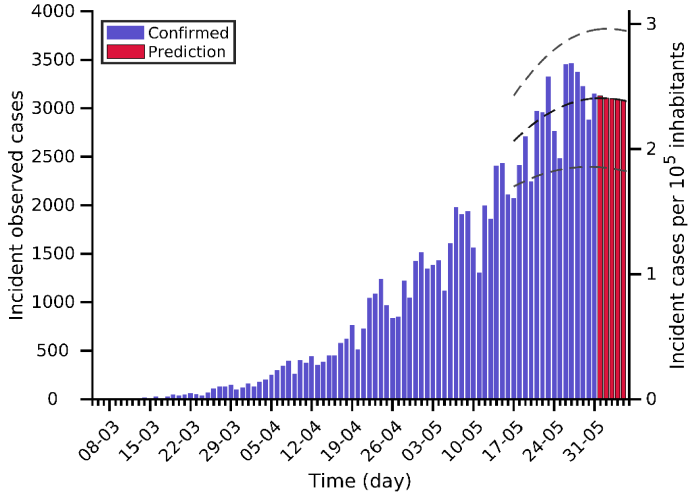
Mexico 31-05-2020. Population: 128.9M. Current cumulated incidence: 70/10^5

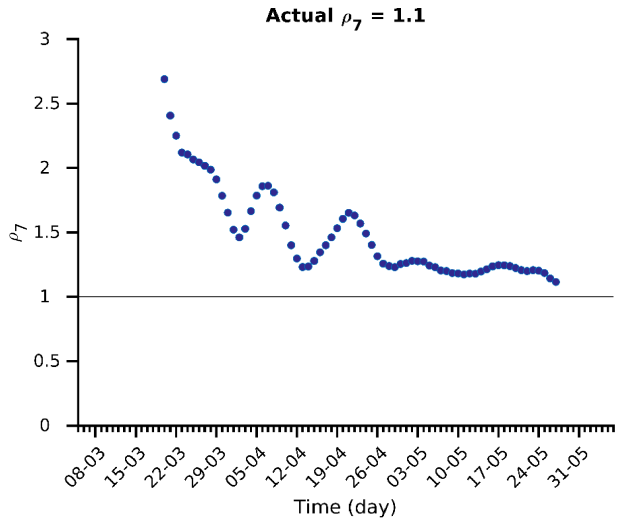


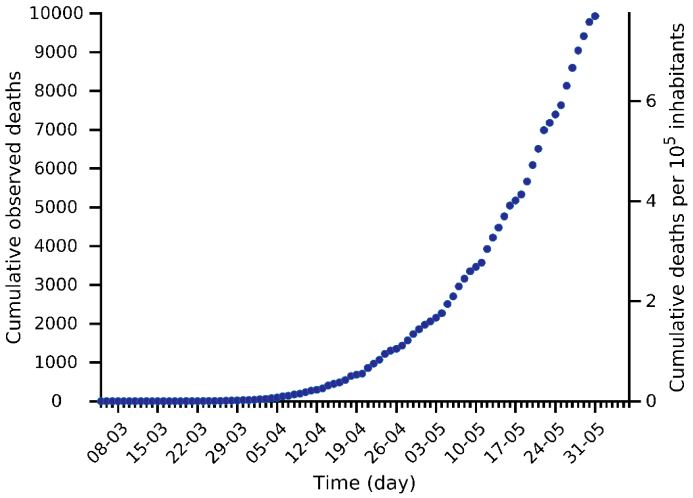


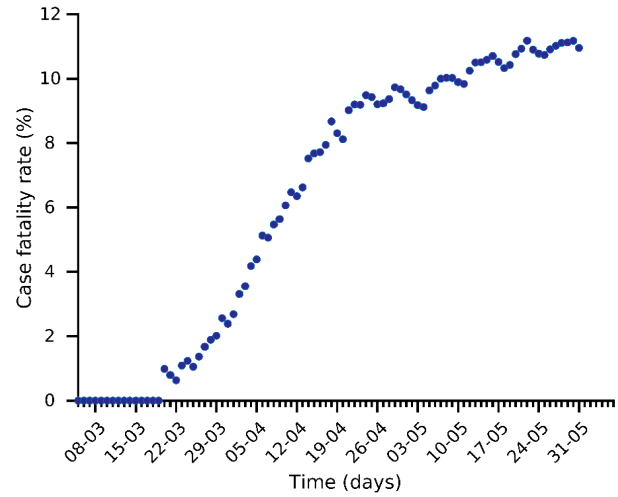




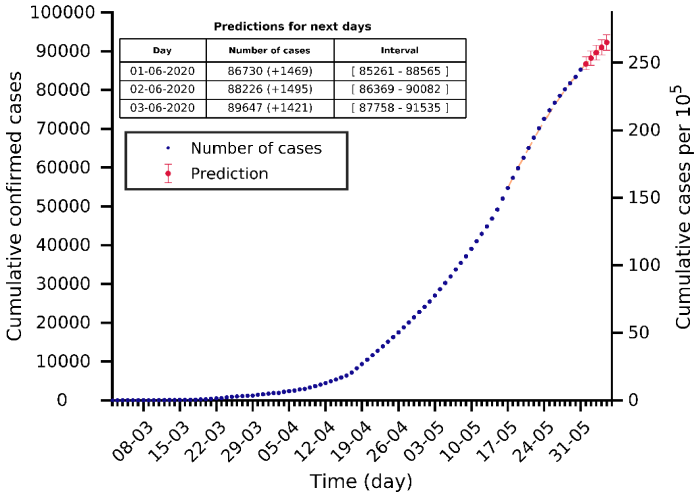


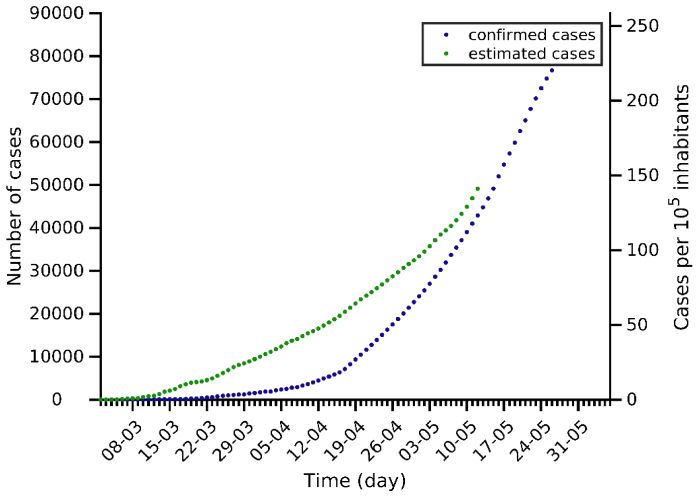


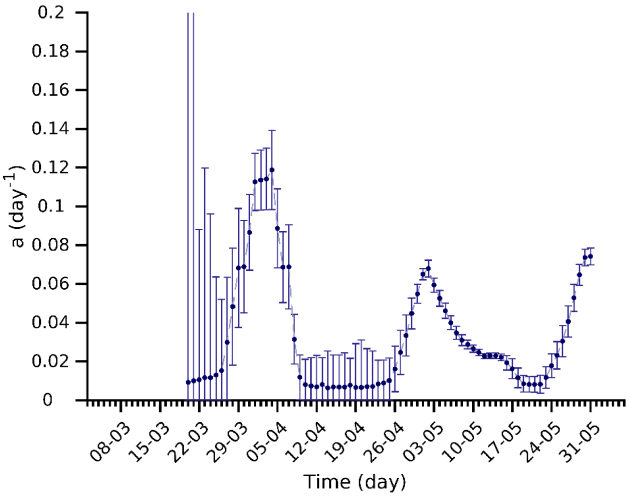


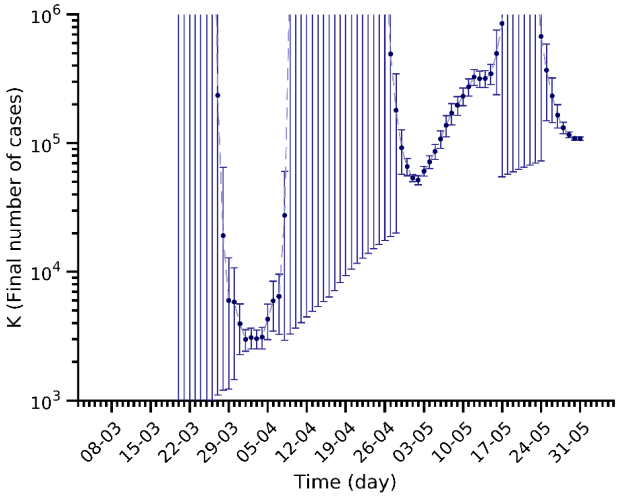


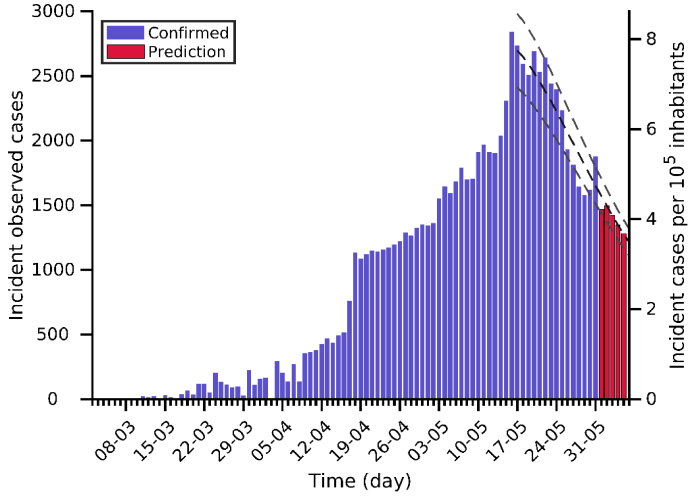
Saudi Arabia 31-05-2020. Population: 34.8M. Current cumulated incidence: 245/10^5

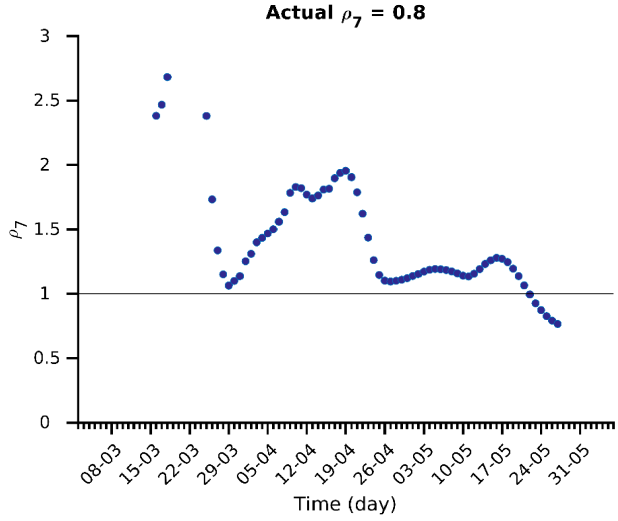


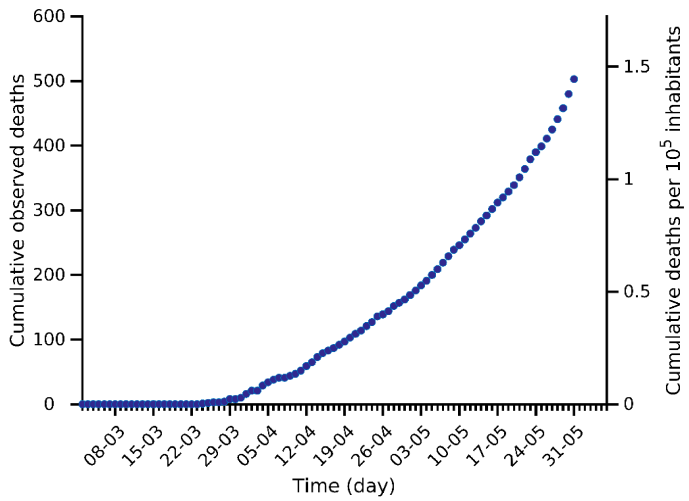


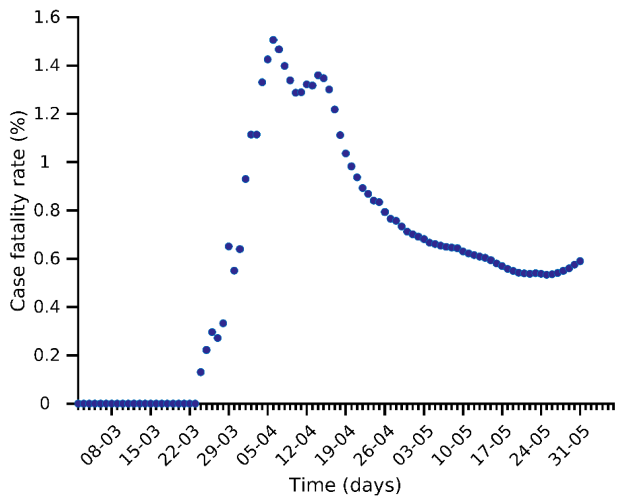




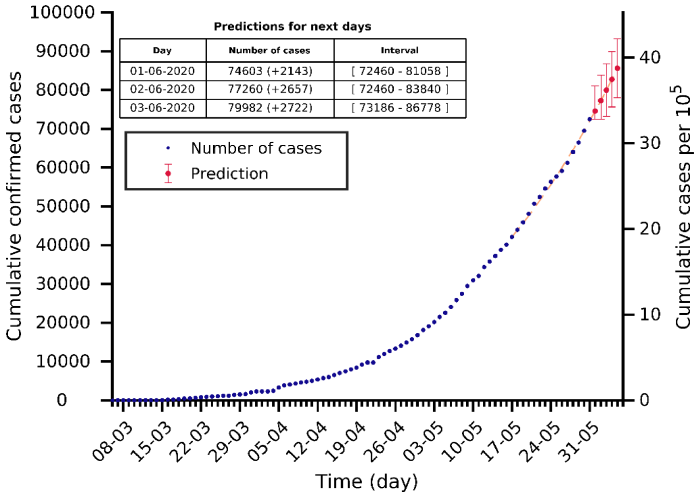


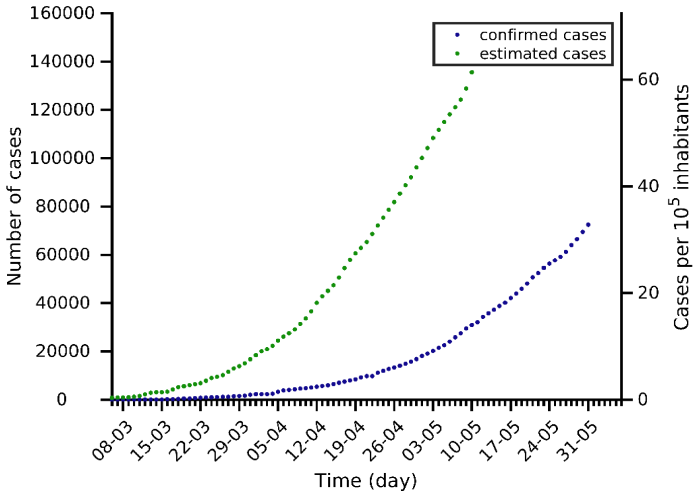


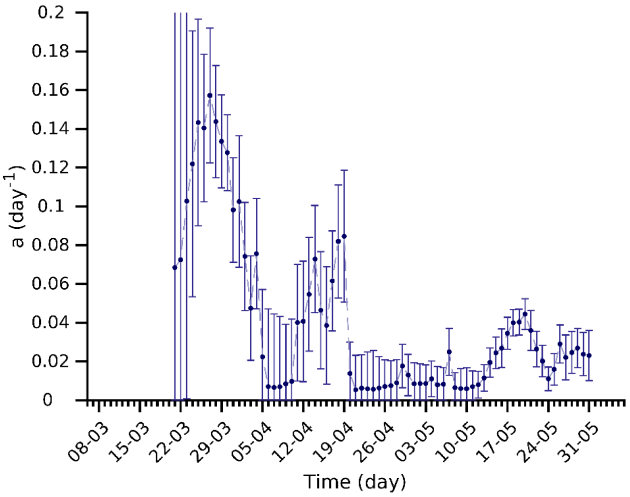


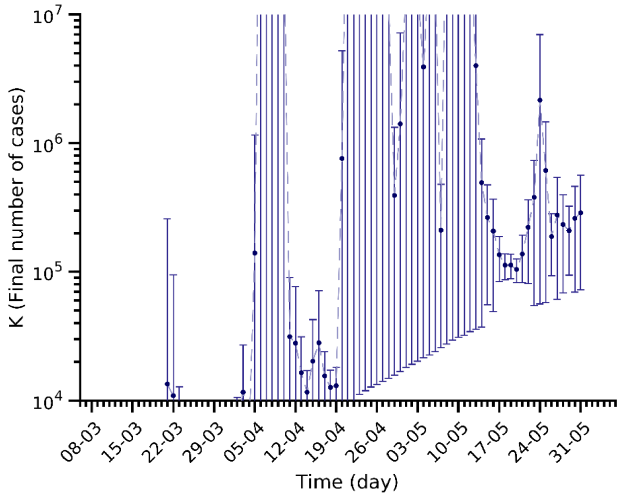


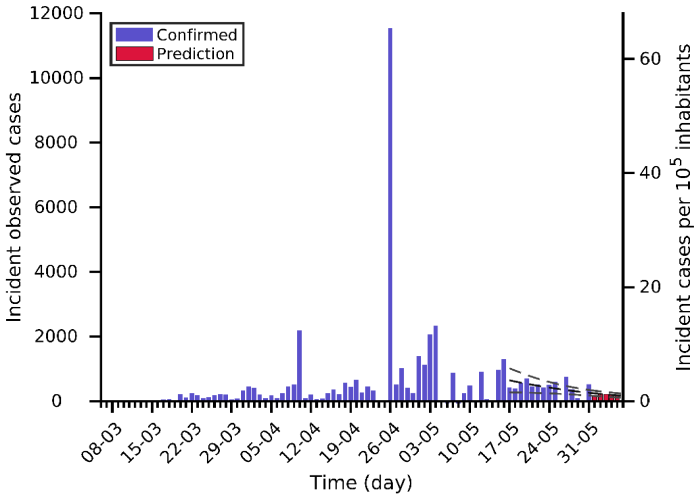
Pakistan 31-05-2020. Population: 220.9M. Current cumulated incidence: $33/10^5$

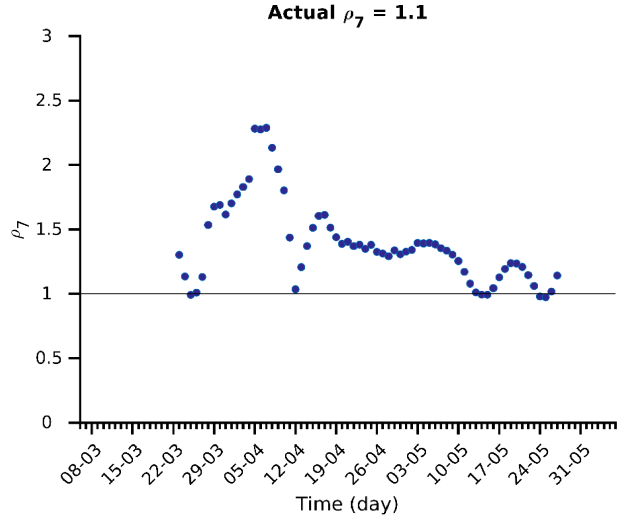


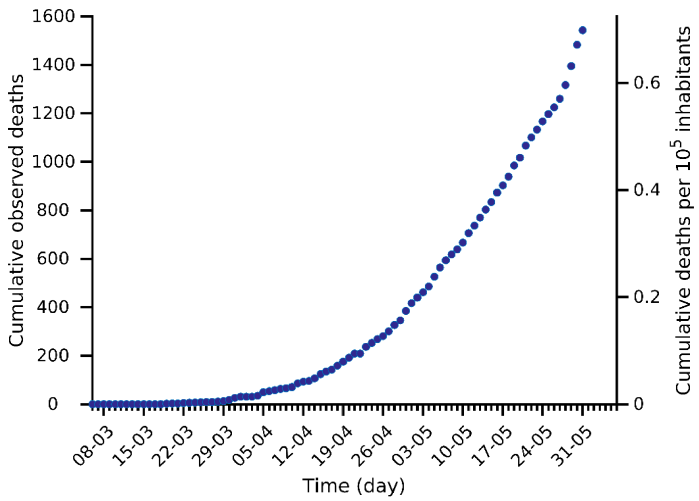


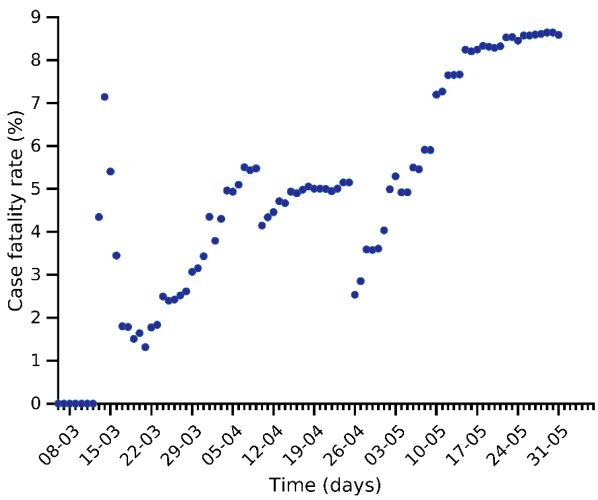




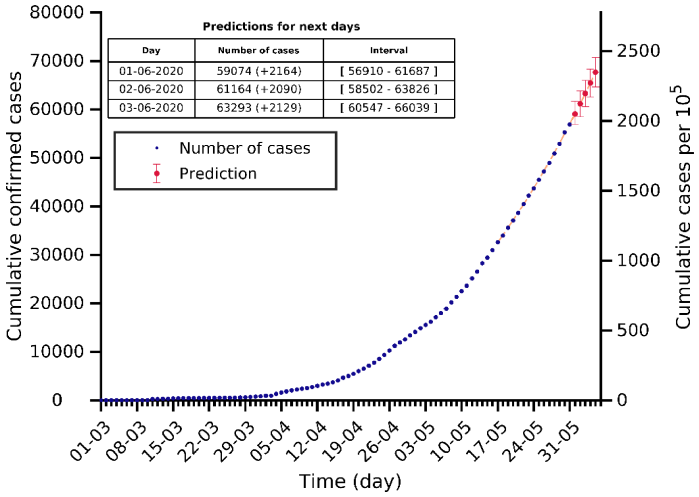


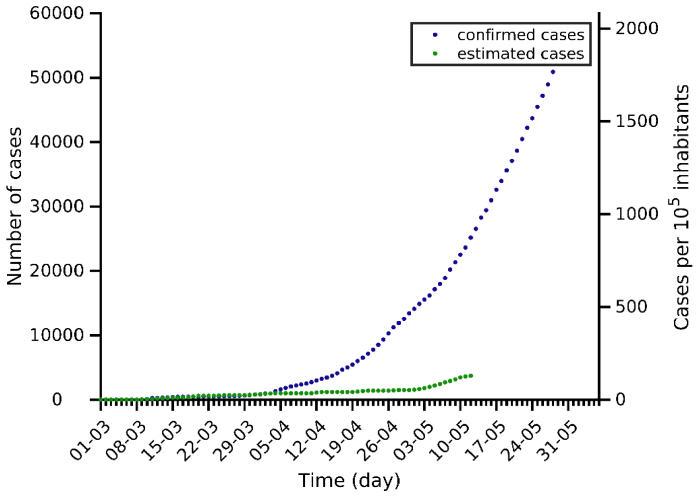


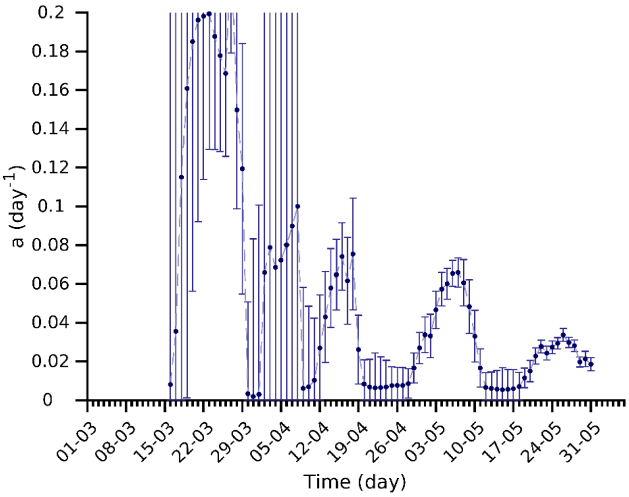


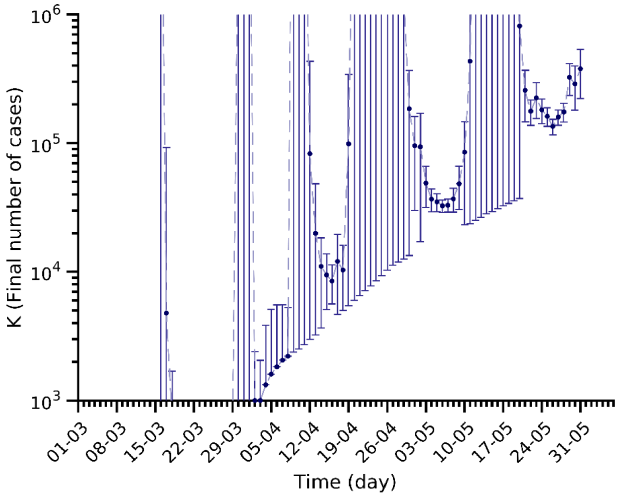


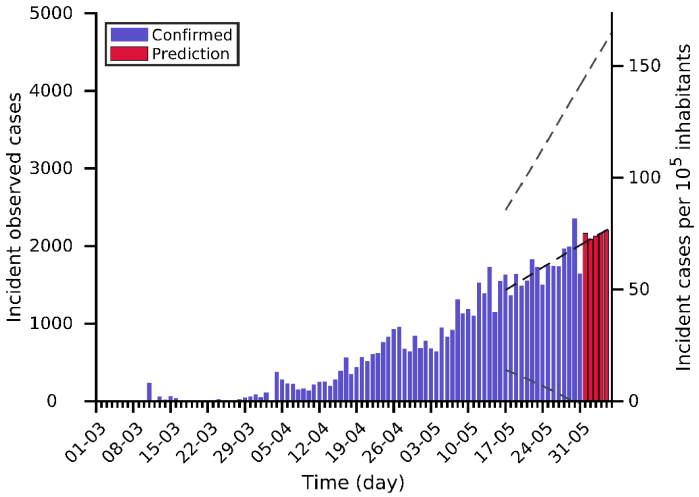
Qatar 31-05-2020. Population: 2.9M. Current cumulated incidence: 1975/10⁵

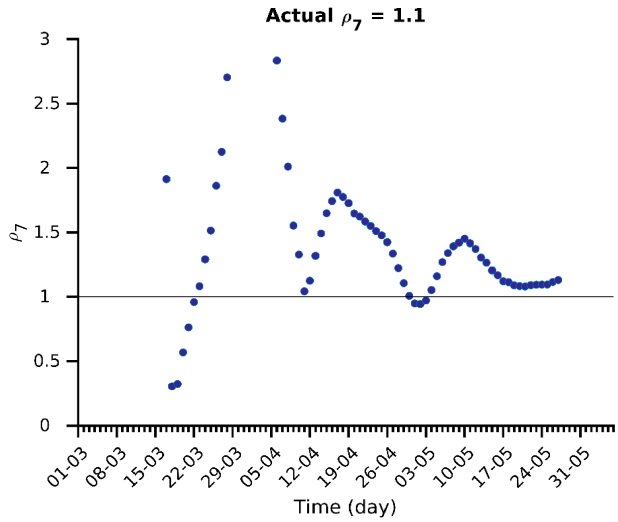


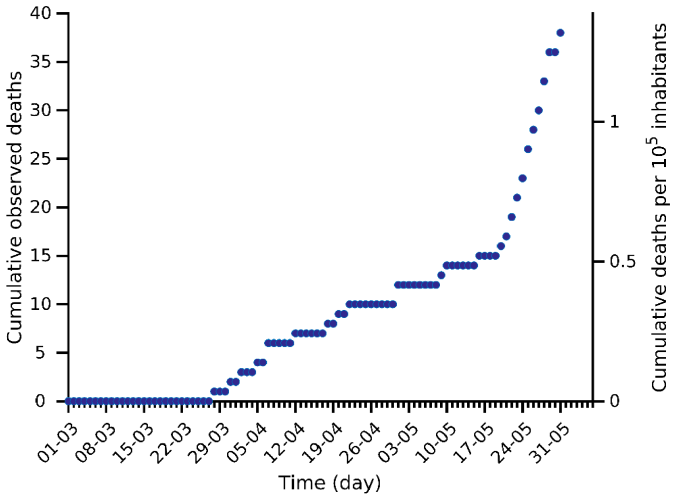


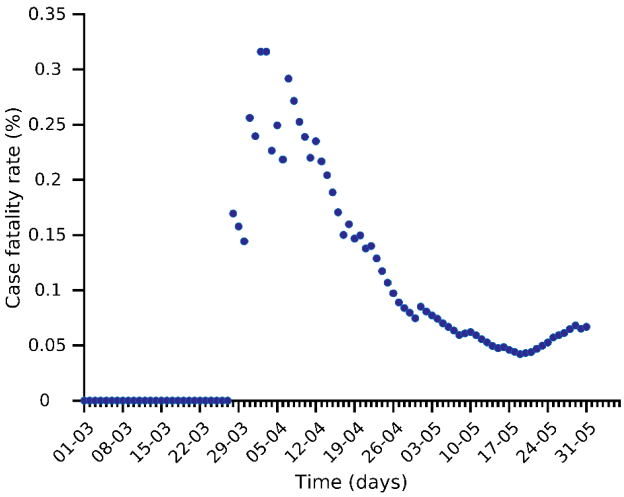




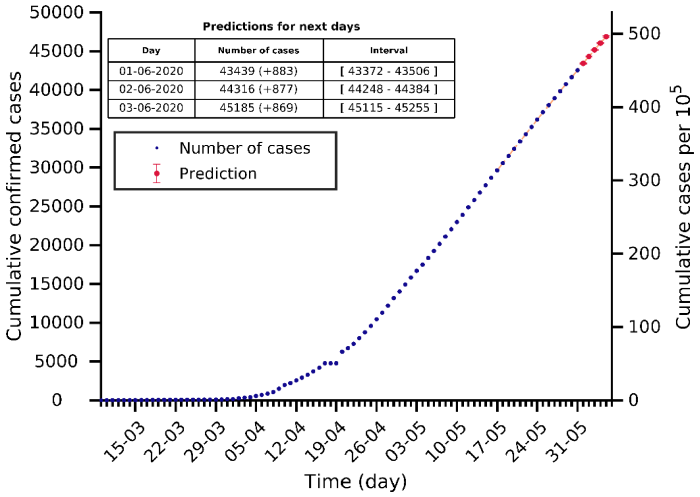


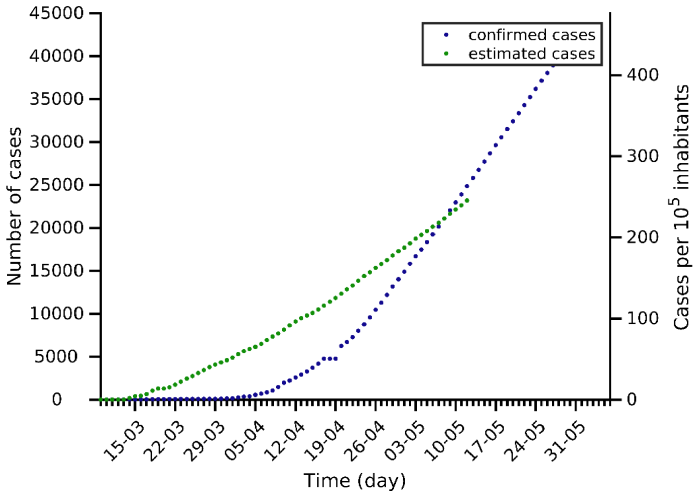


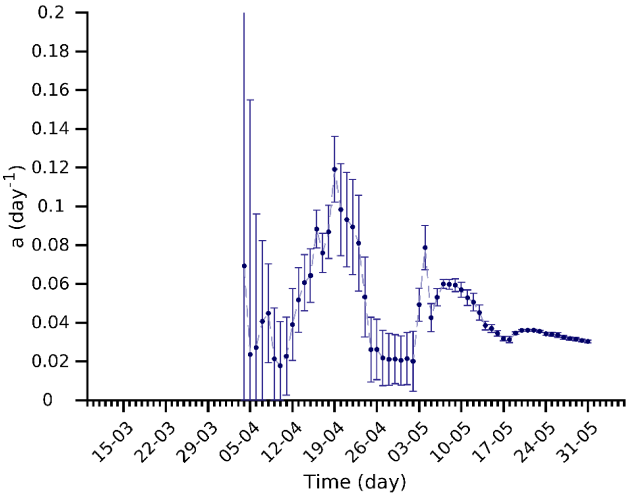


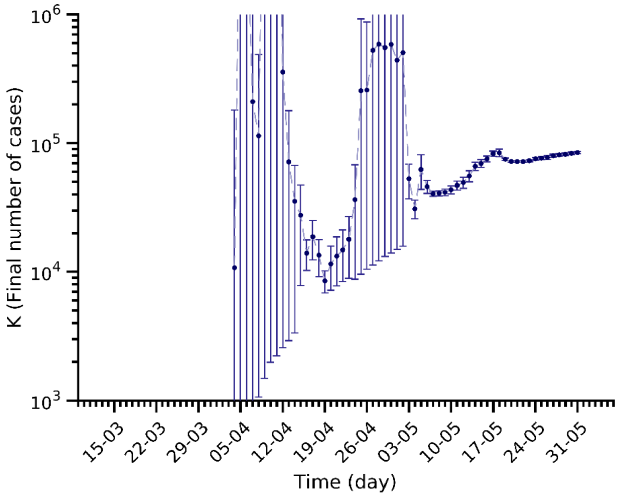


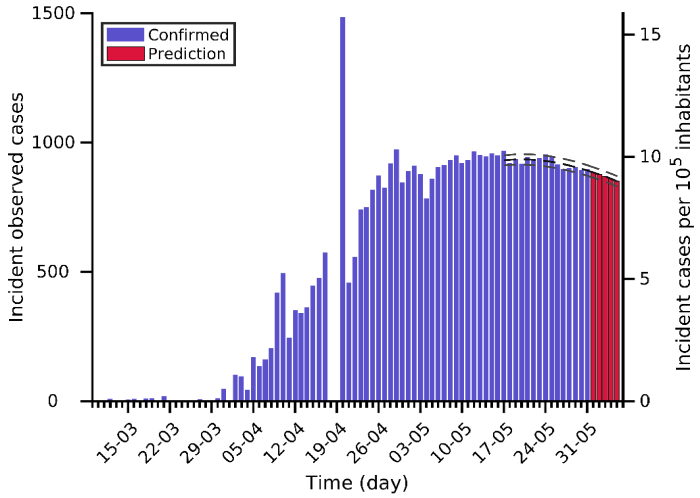
Belarus 31-05-2020. Population: 9.4M. Current cumulated incidence: 450/10^5

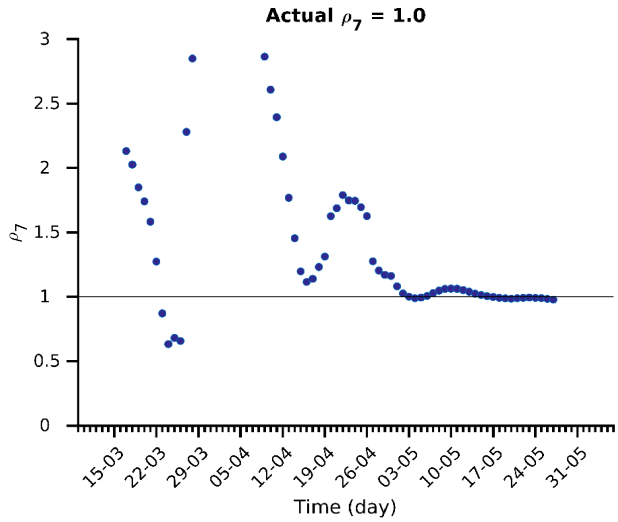


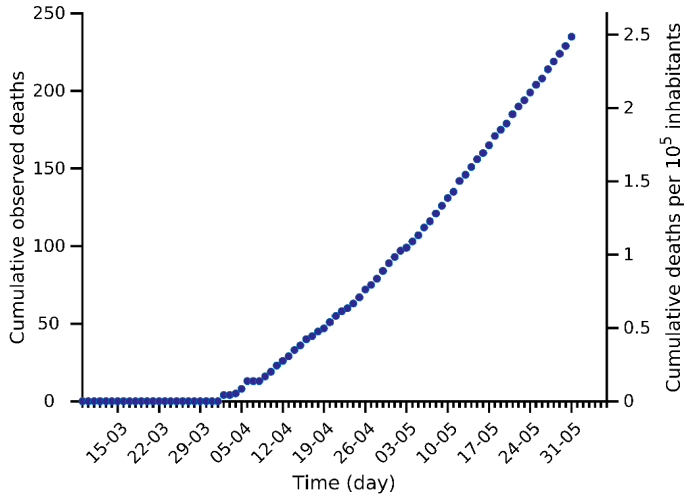


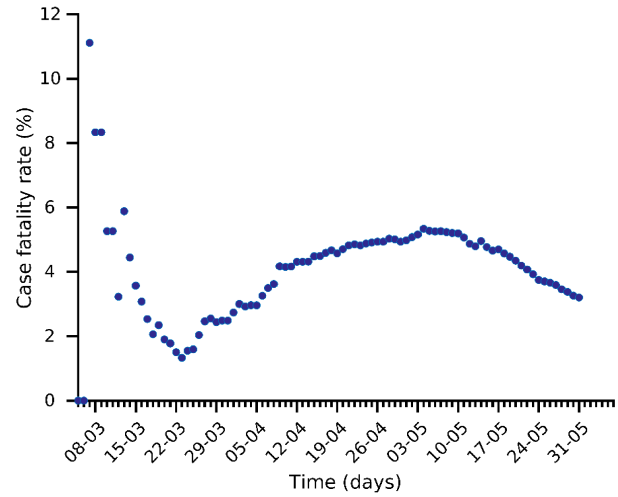




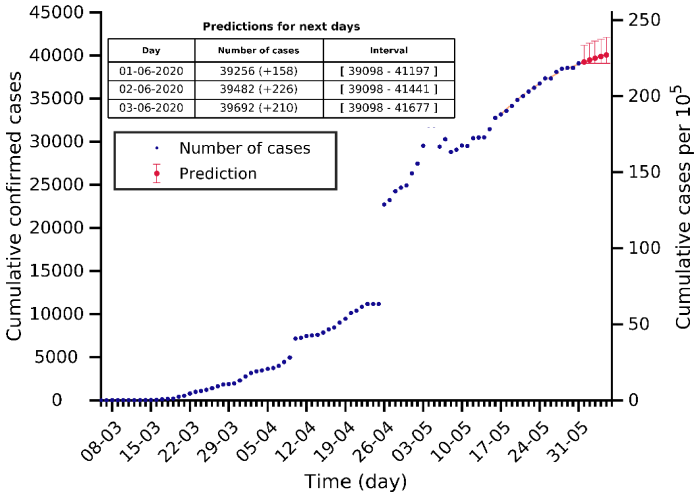


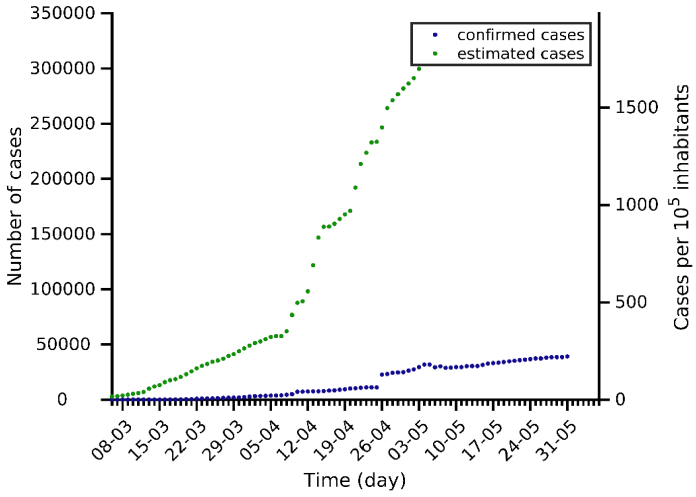


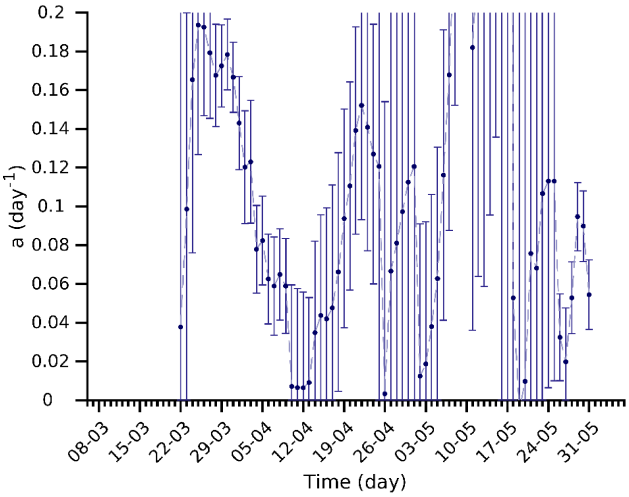


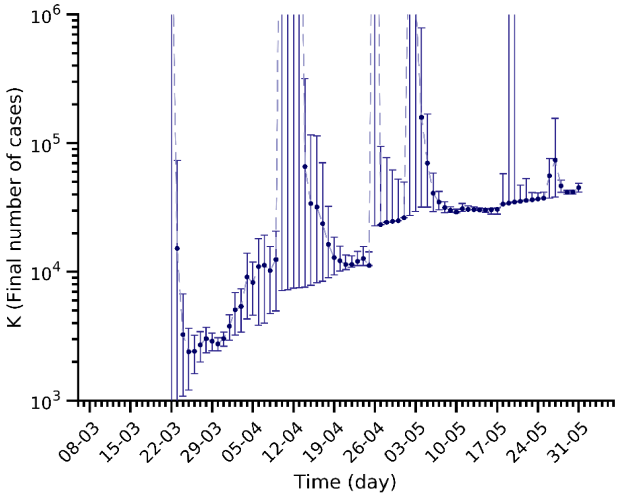


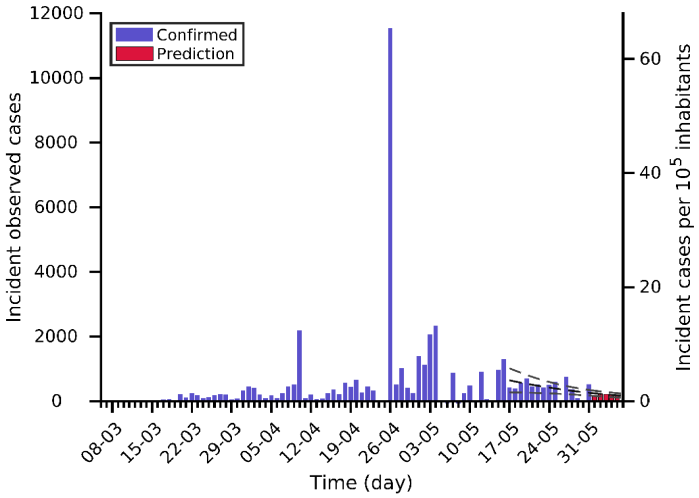
Ecuador 31-05-2020. Population: 17.6M. Current cumulated incidence: 222/10^5

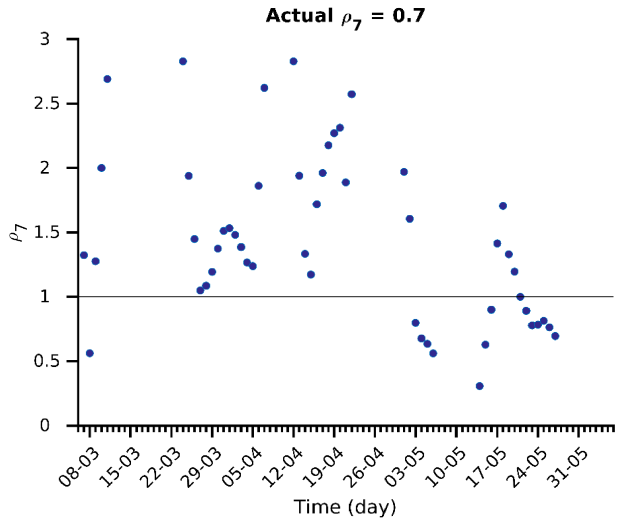


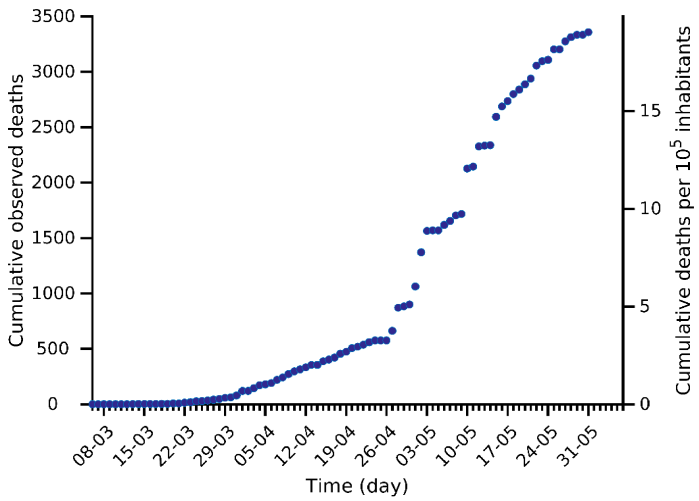


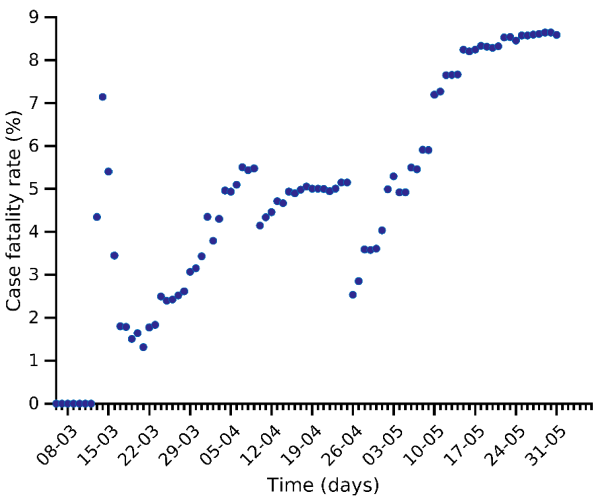




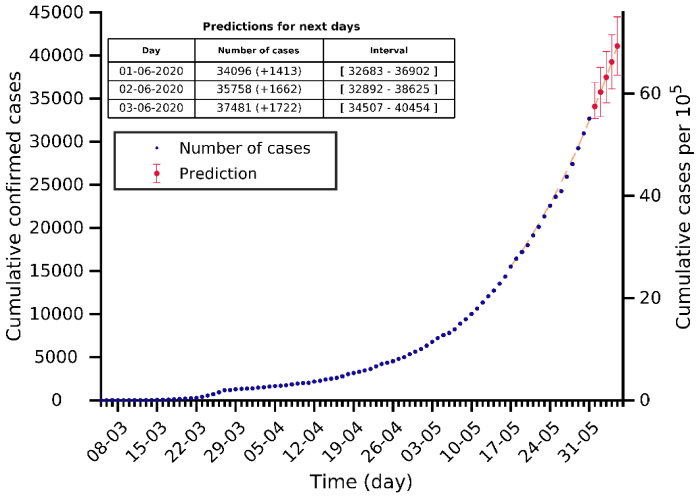


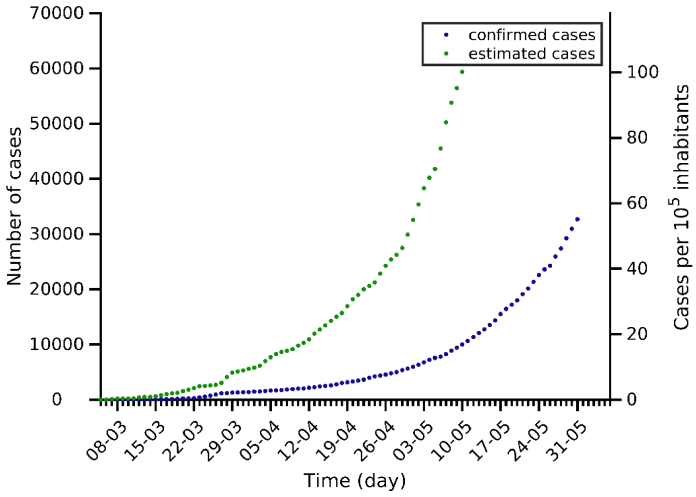


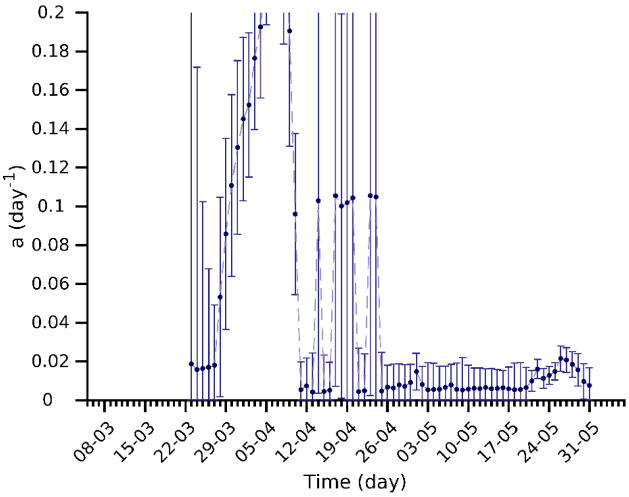


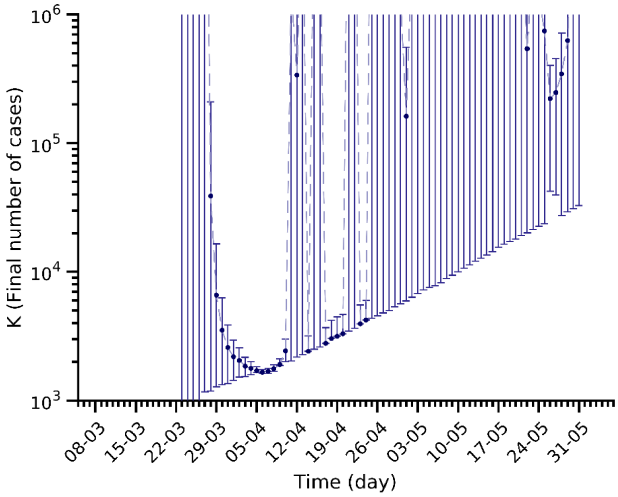


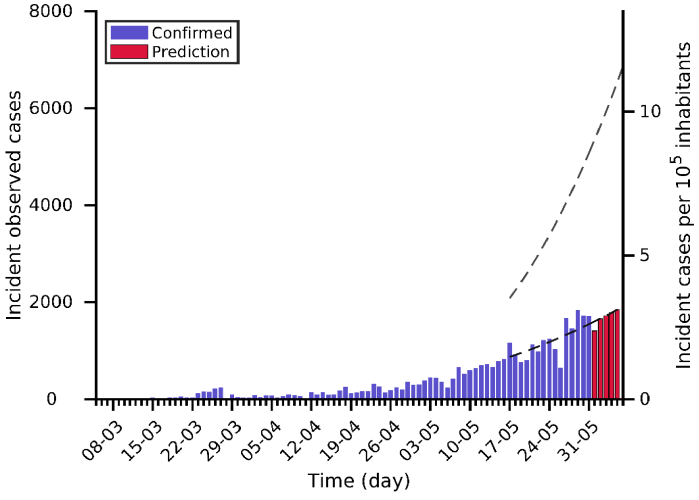
South Africa 31-05-2020. Population: 59.3M. Current cumulated incidence: $55/10^5$

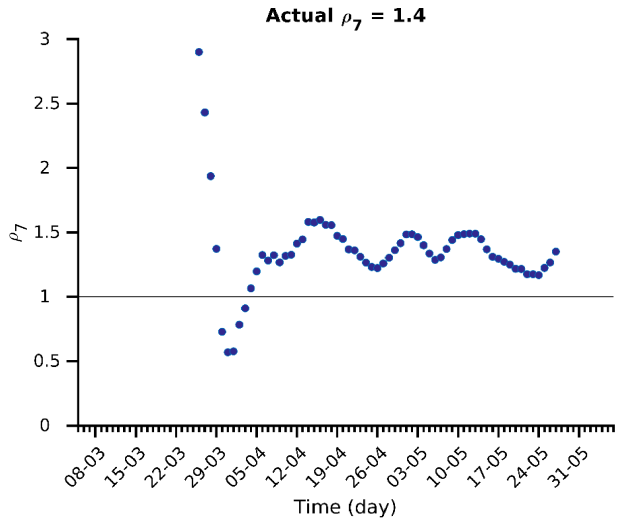


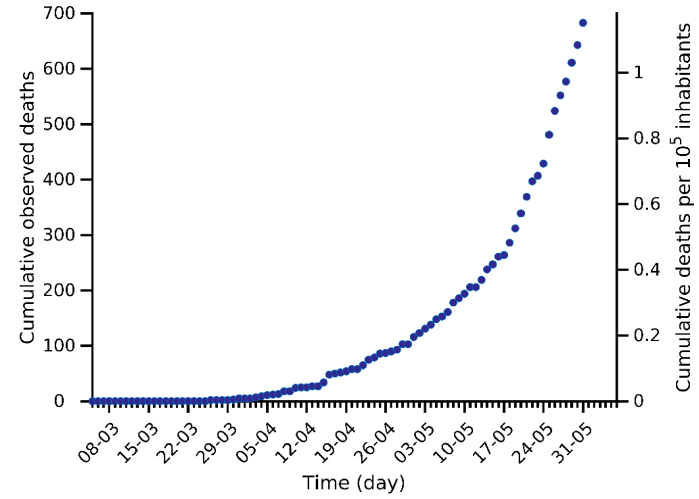


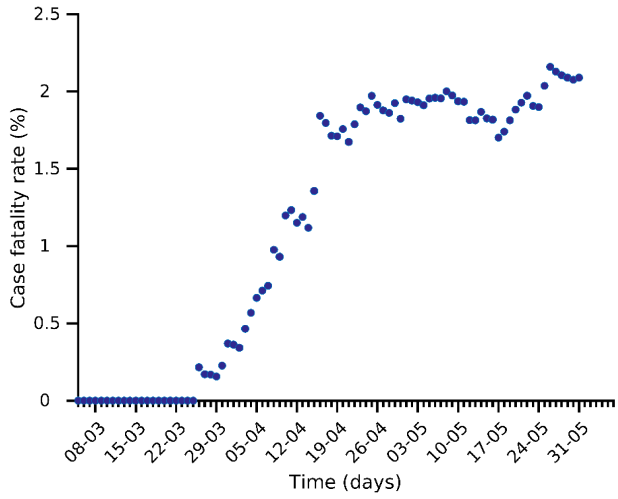




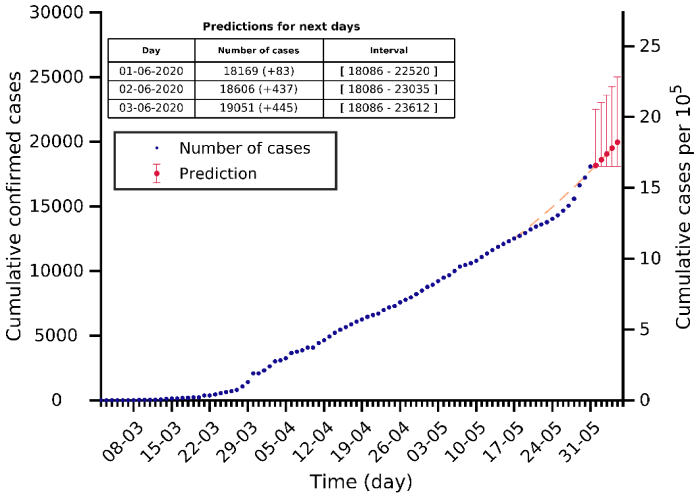


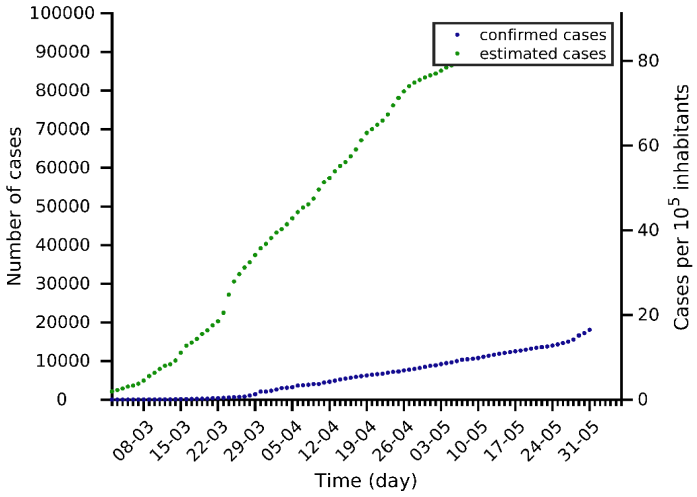


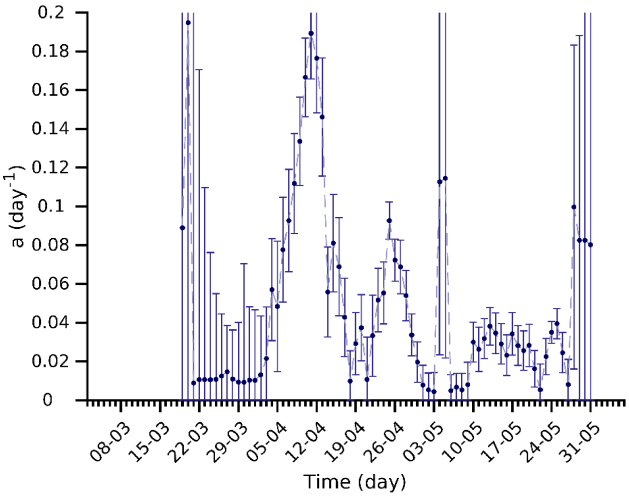


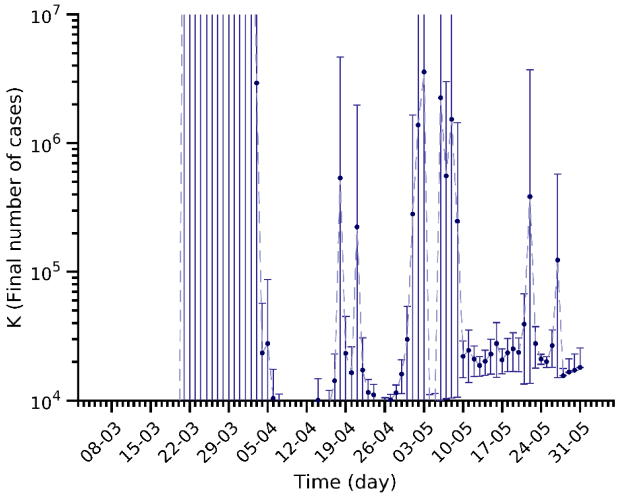


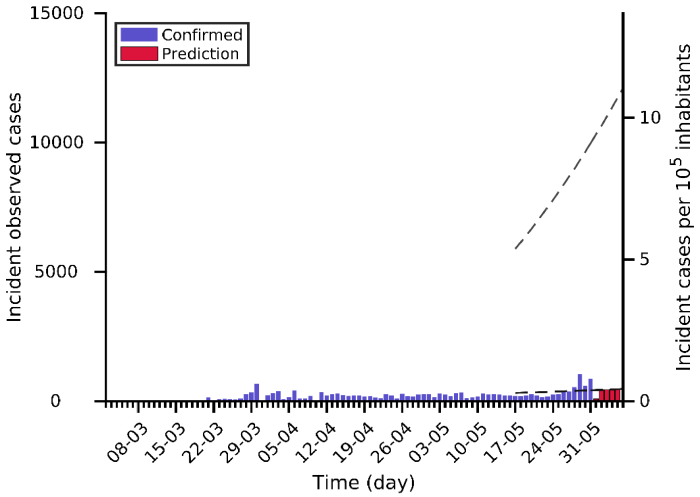
Philippines 31-05-2020. Population: 109.6M. Current cumulated incidence: $17/10^5$

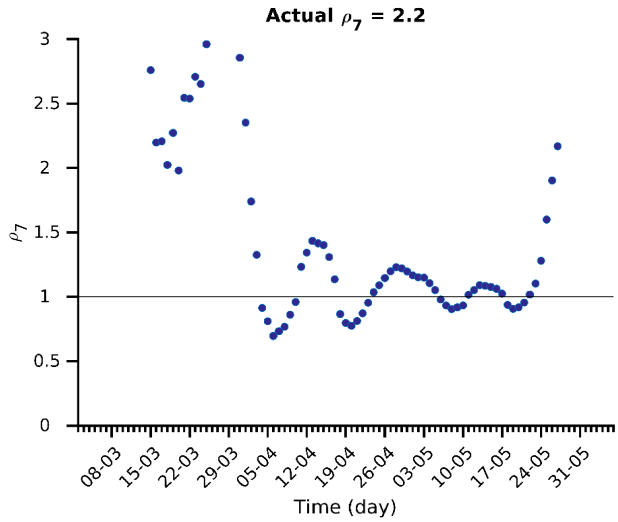


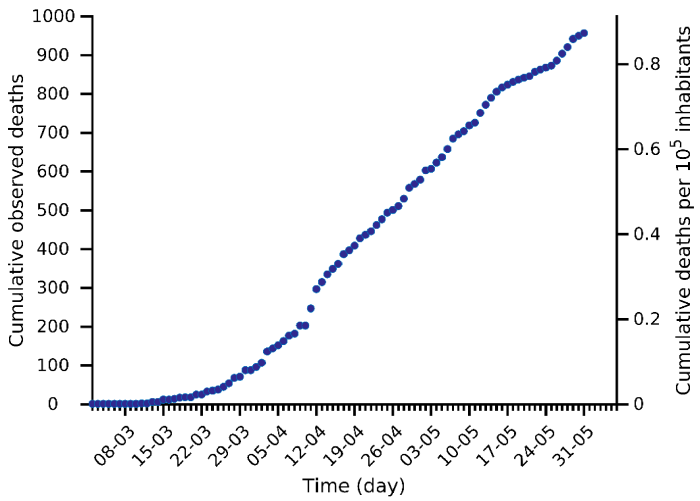


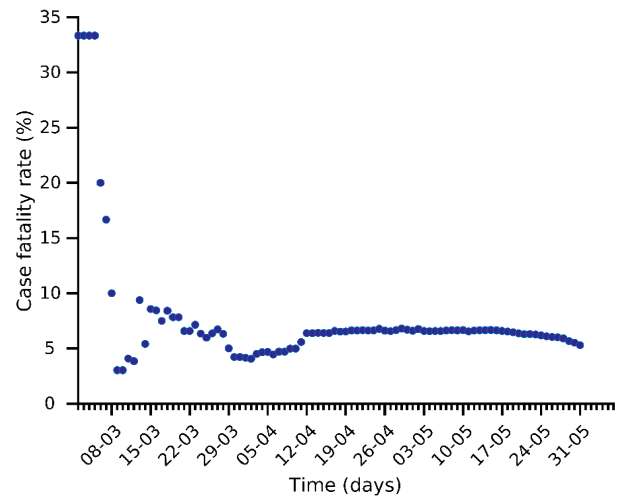




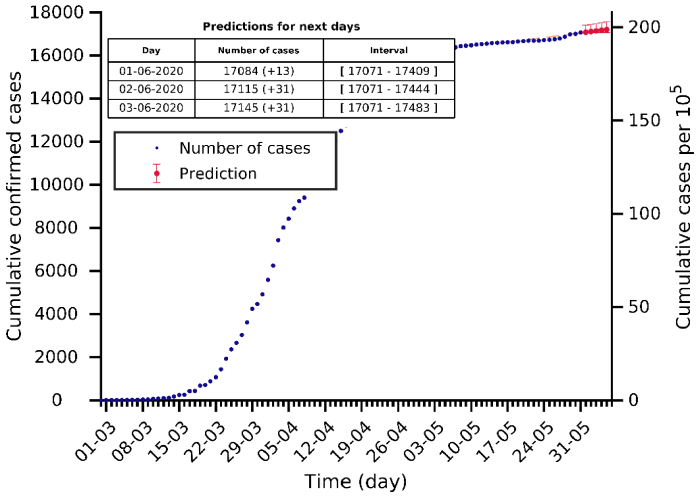


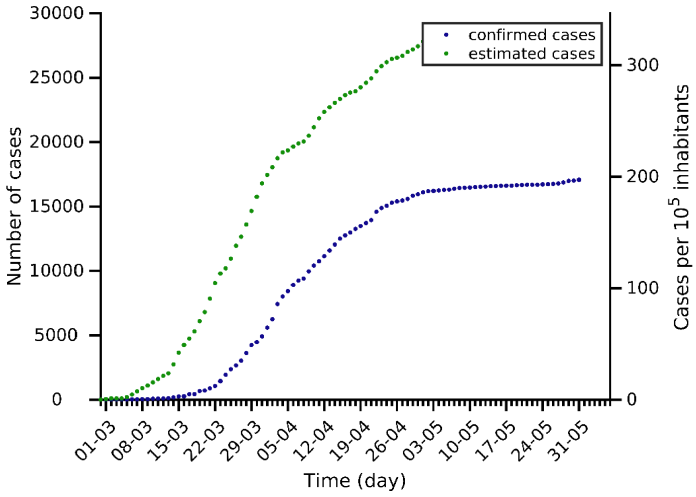


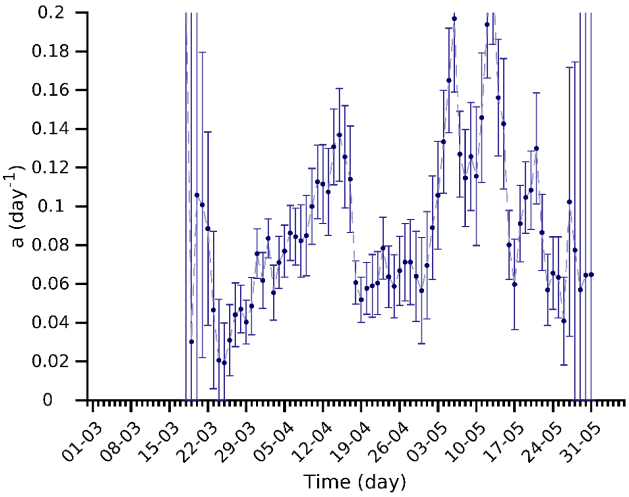


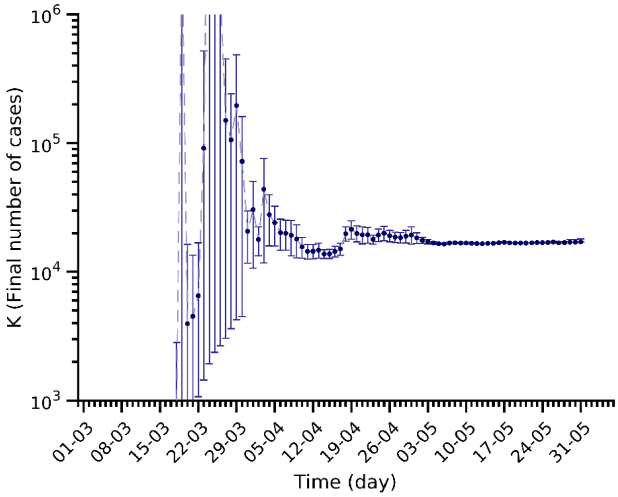


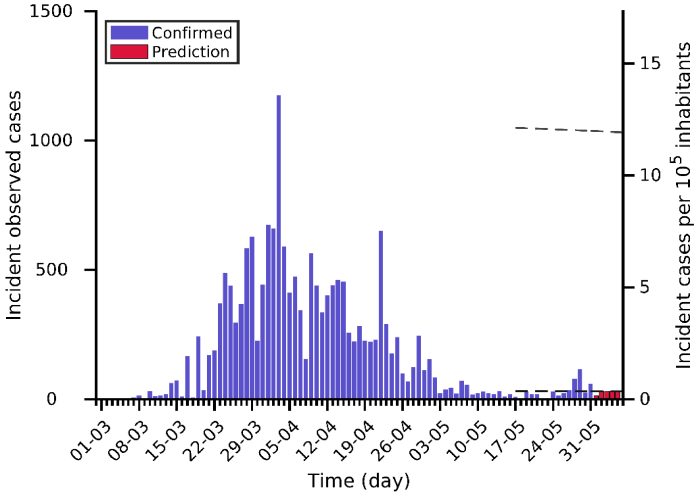
Israel 31-05-2020. Population: 8.7M. Current cumulated incidence: 197/10^5

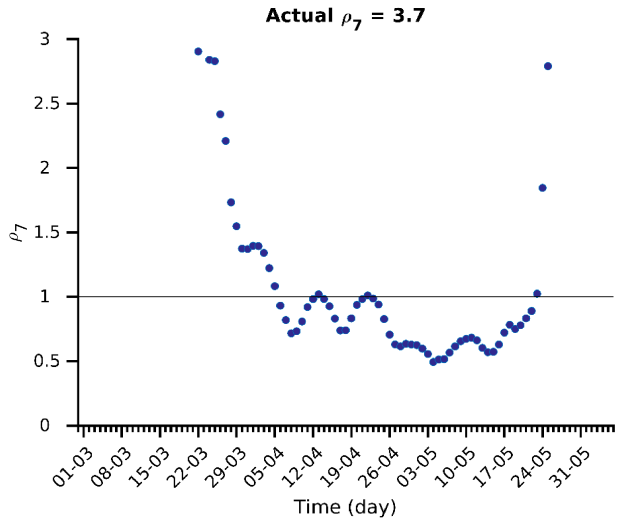


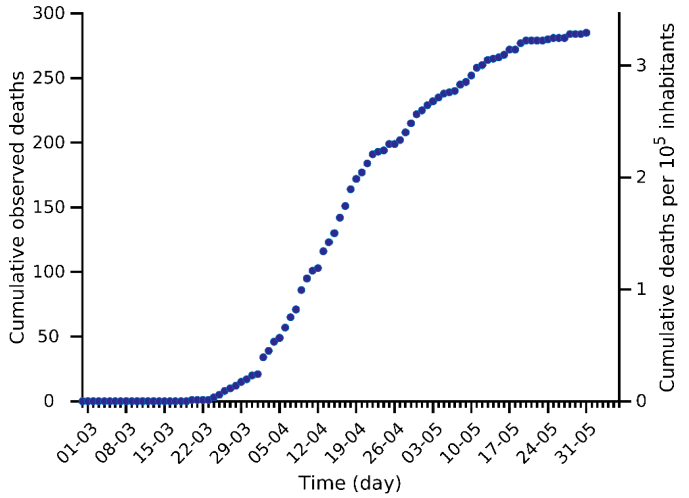


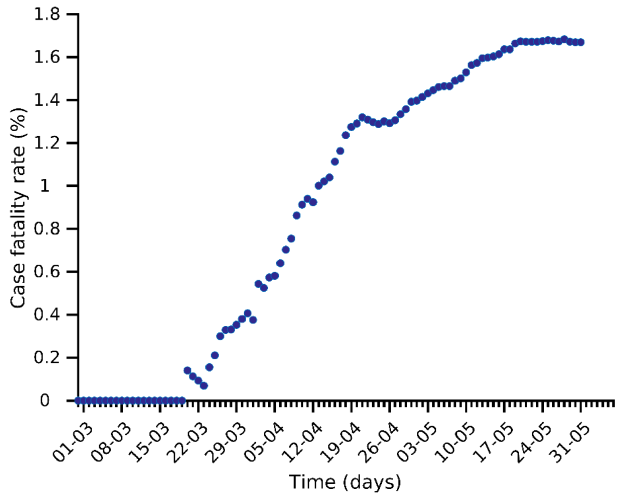




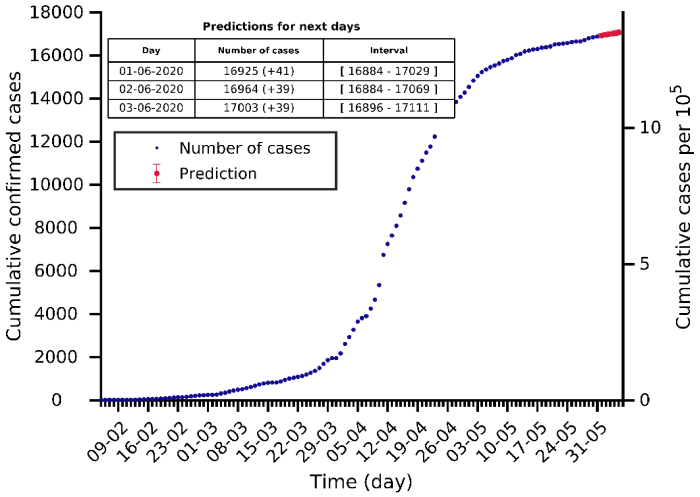


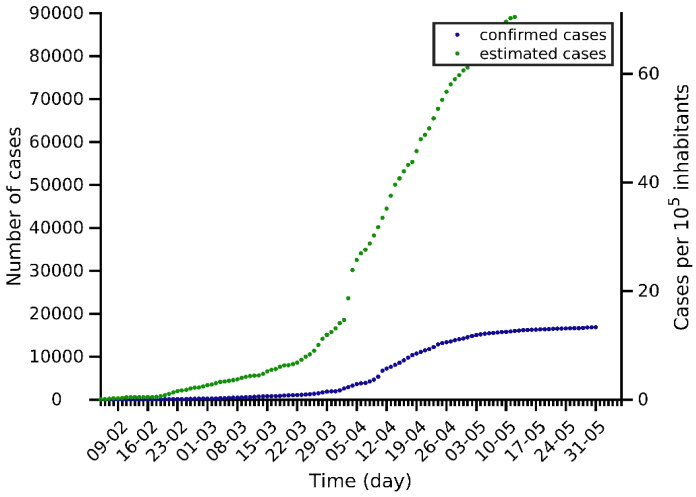


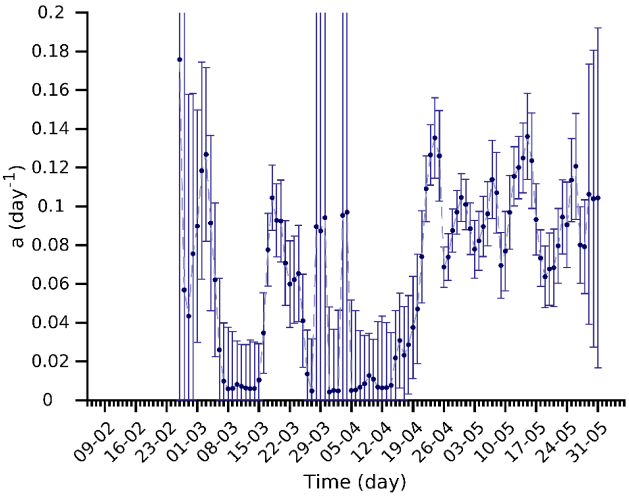


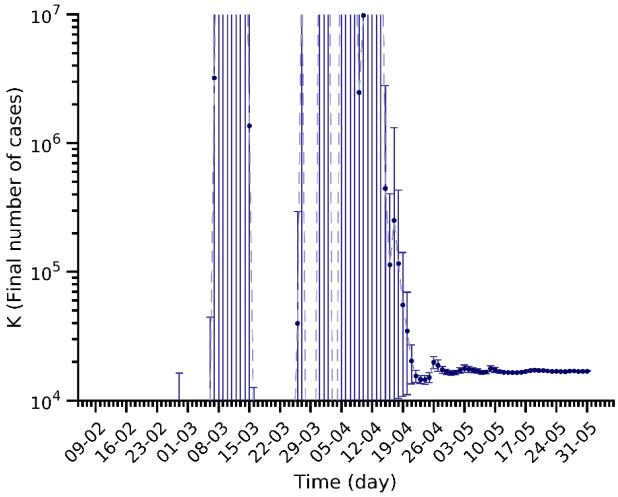


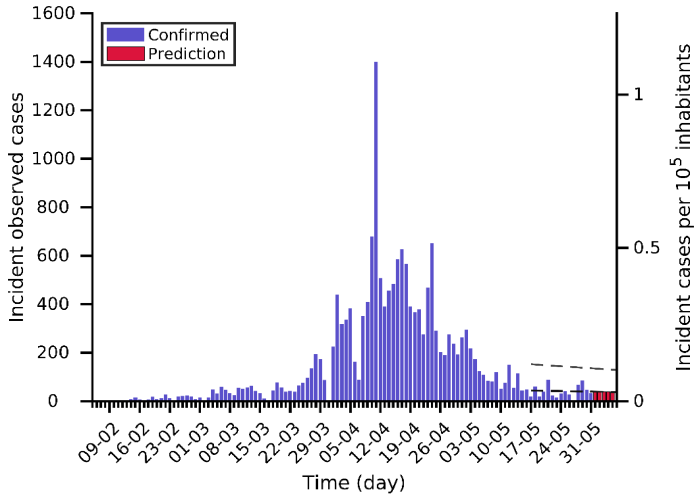
Japan 31-05-2020. Population: 126.5M. Current cumulated incidence: 13/10^5

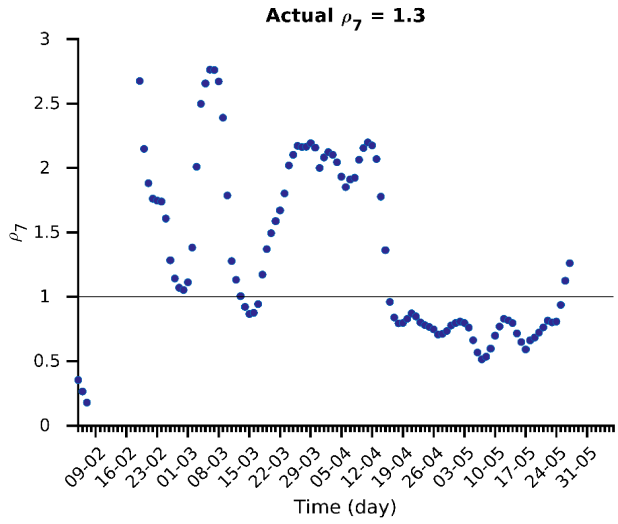


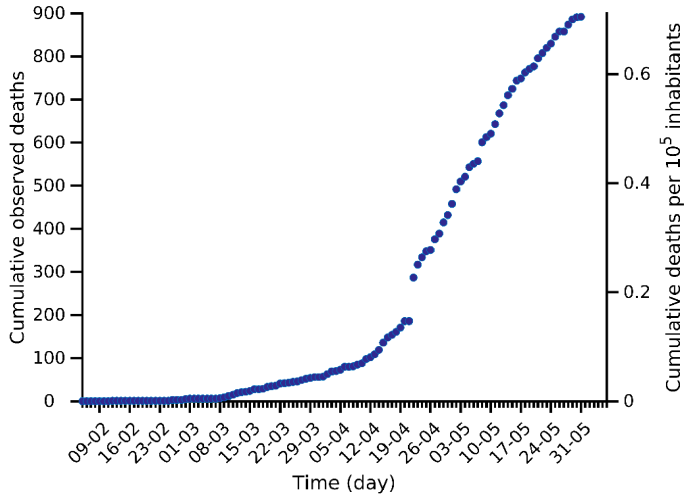


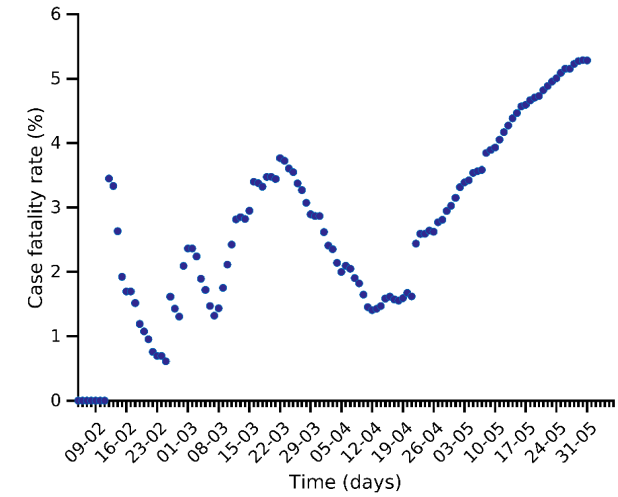




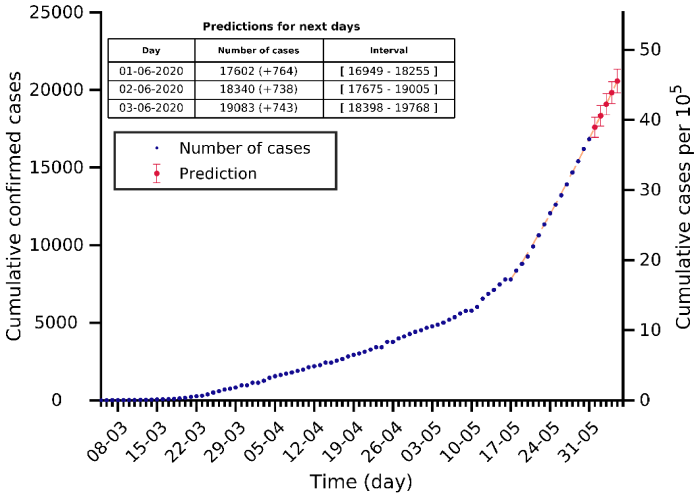


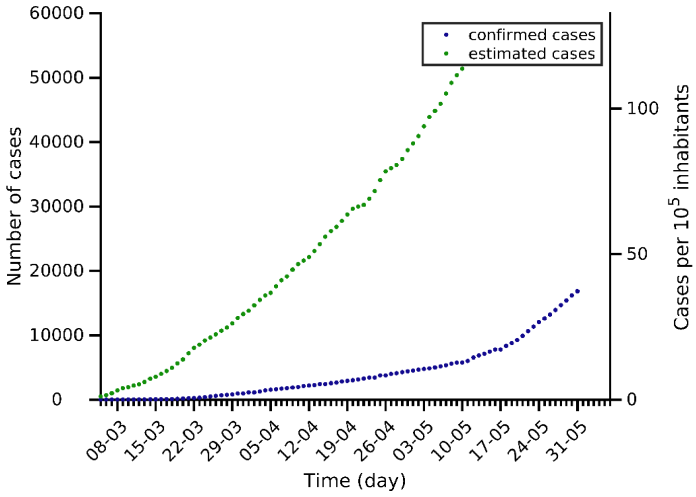


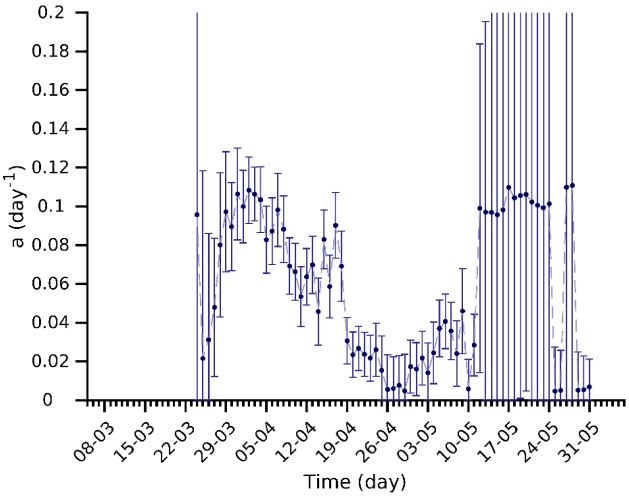


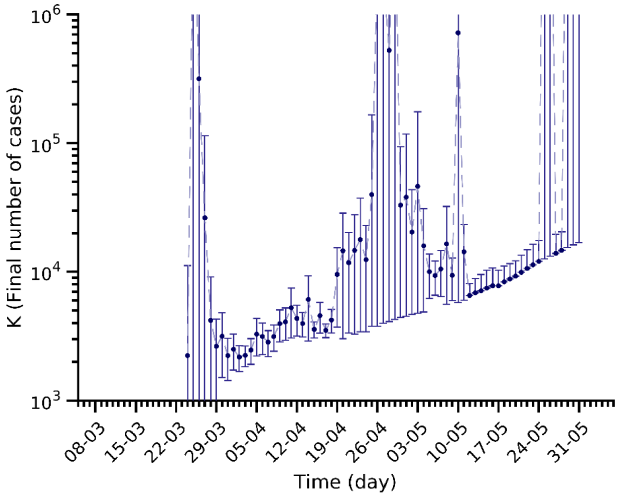


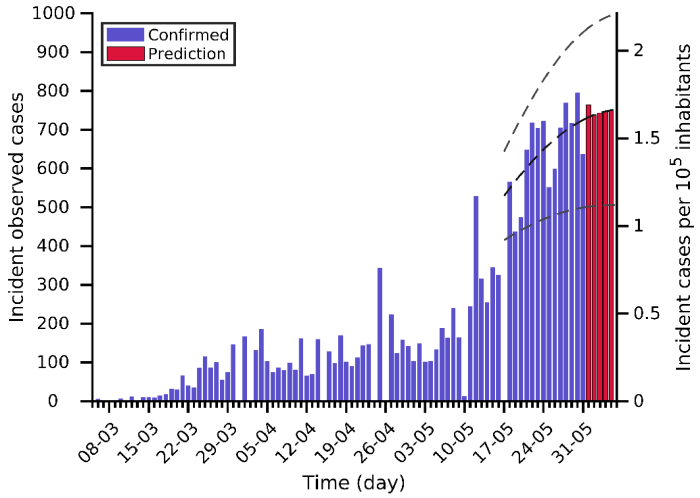
Argentina 31-05-2020. Population: 45.2M. Current cumulated incidence: $37/10^5$

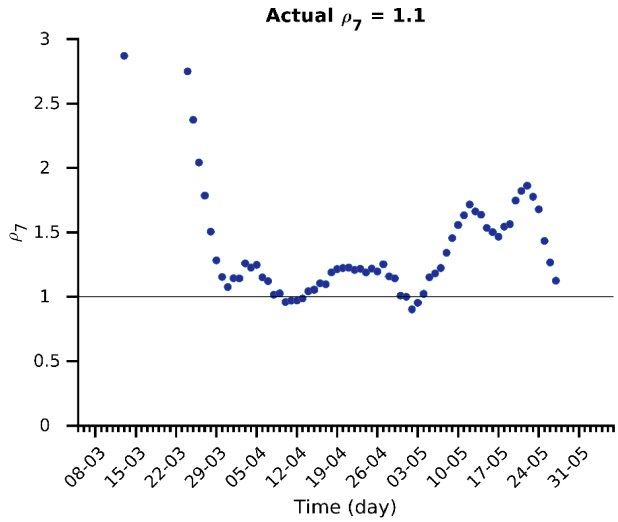


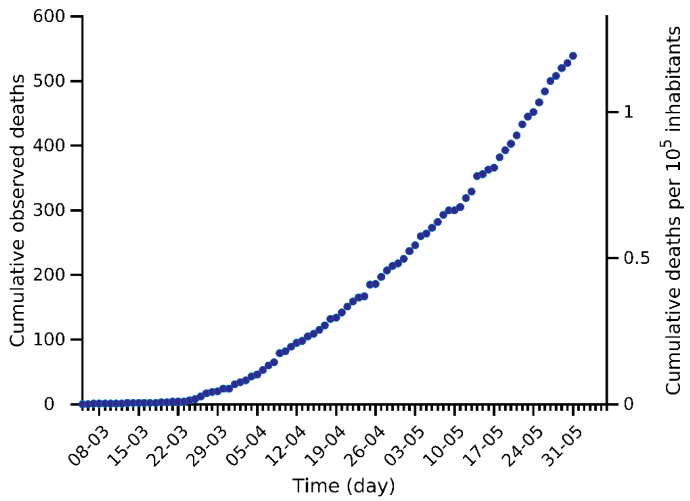


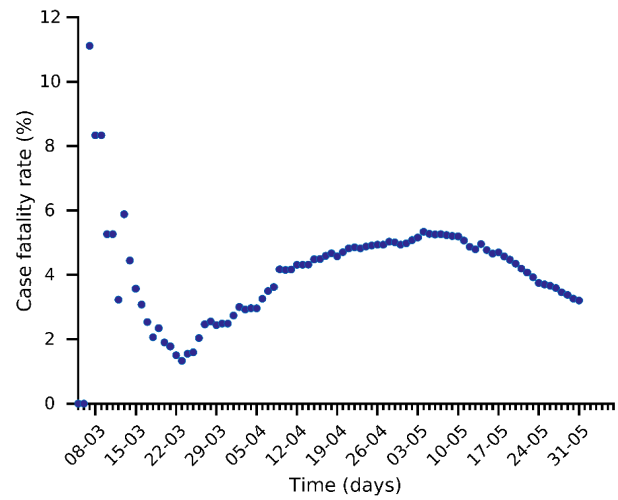




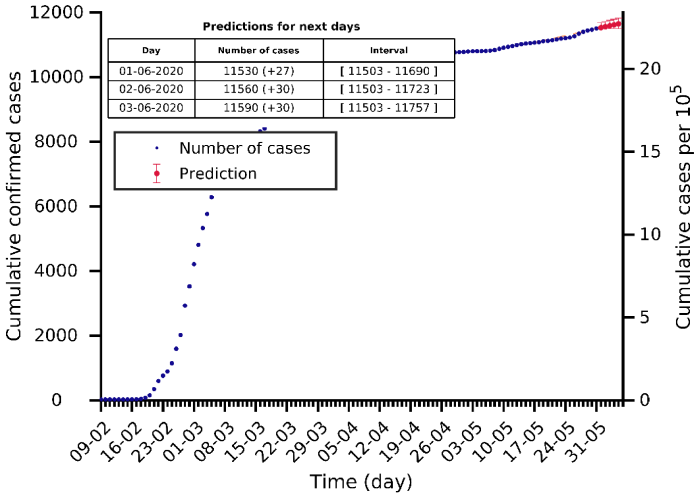


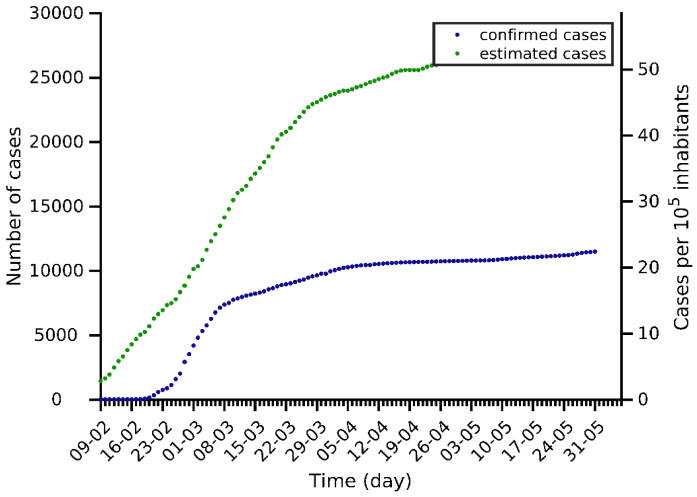


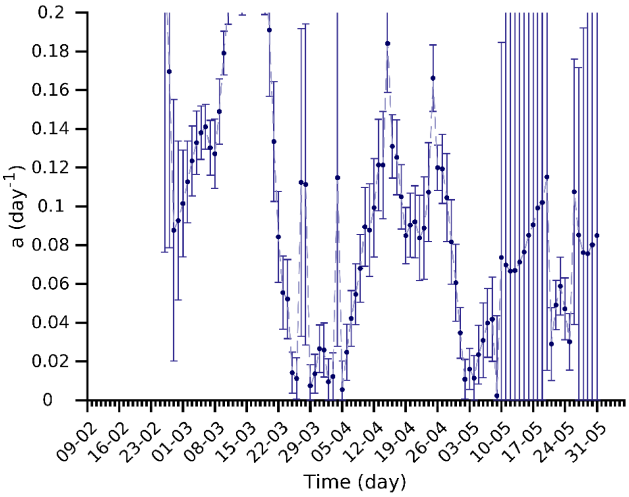


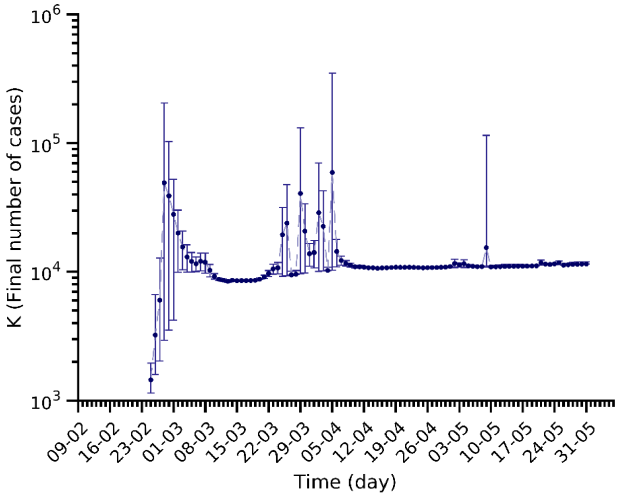


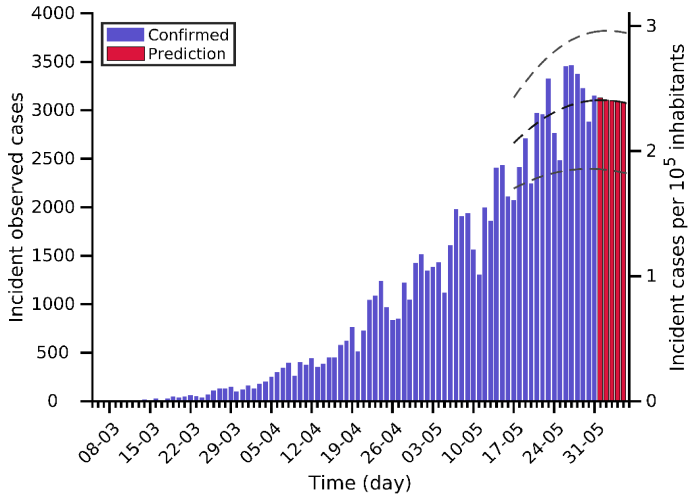
South Korea 31-05-2020. Population: 51.3M. Current cumulated incidence: $22/10^5$

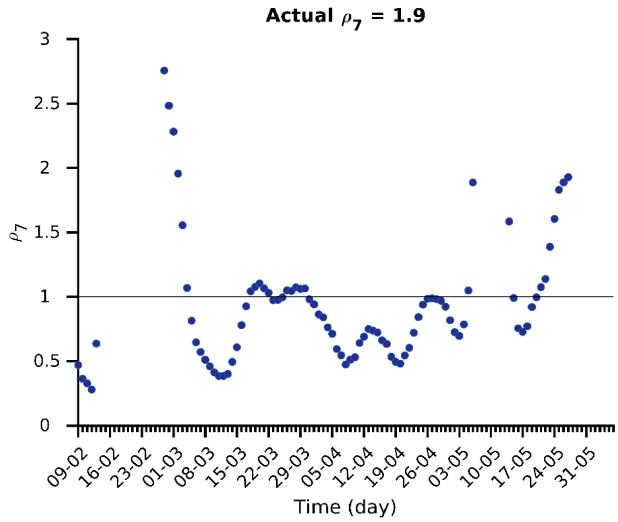


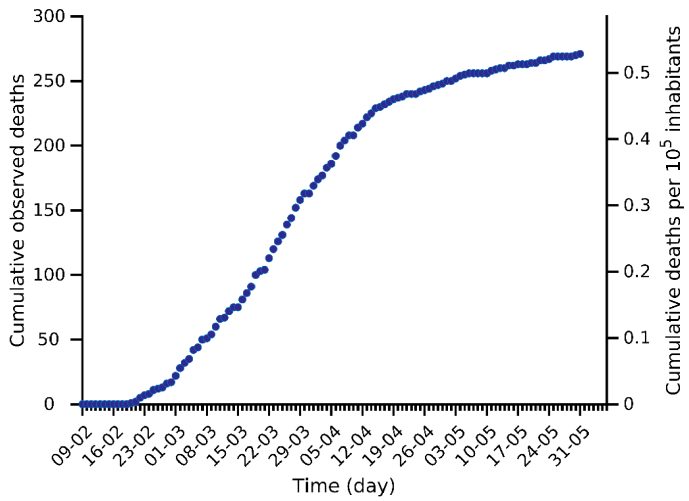


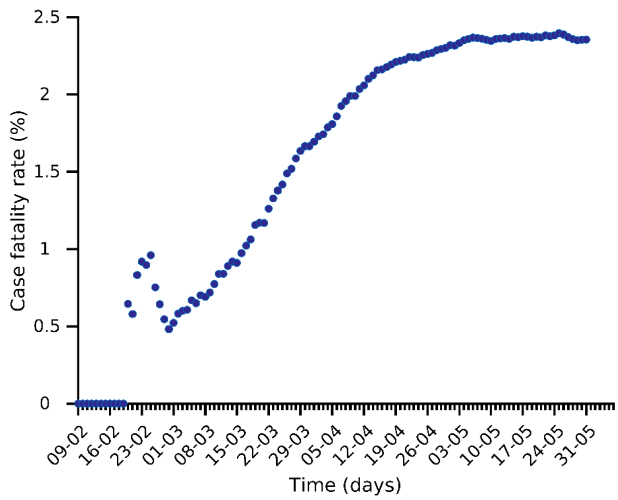




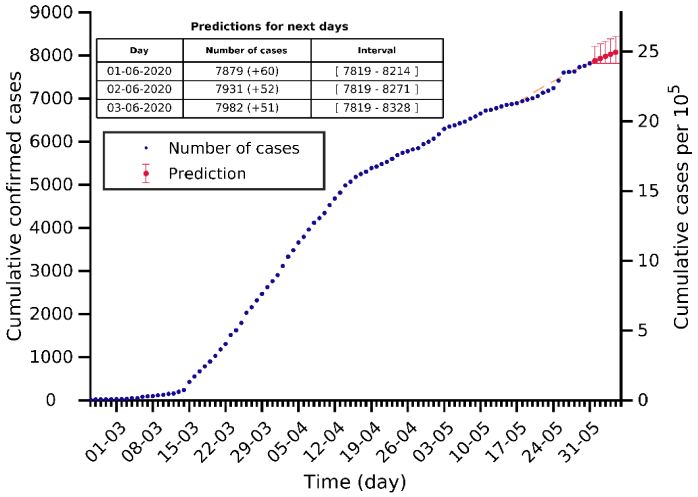


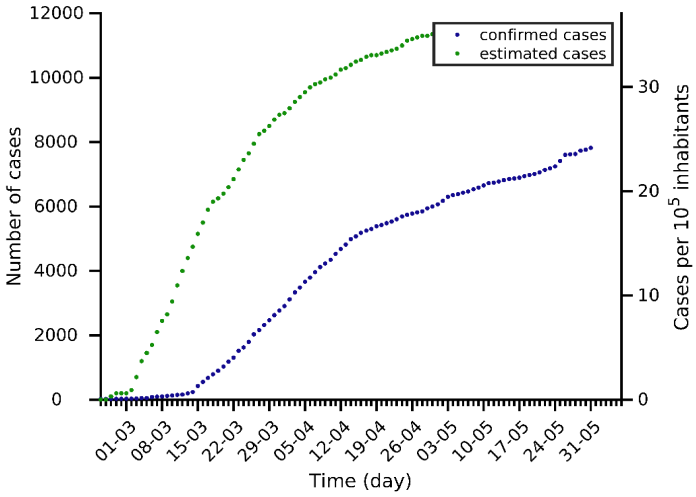


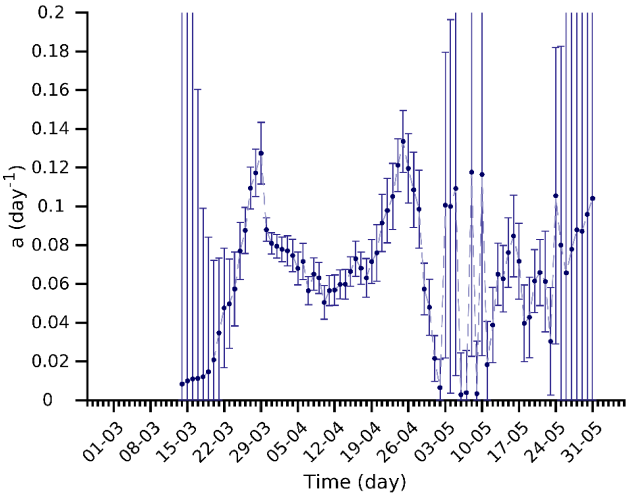


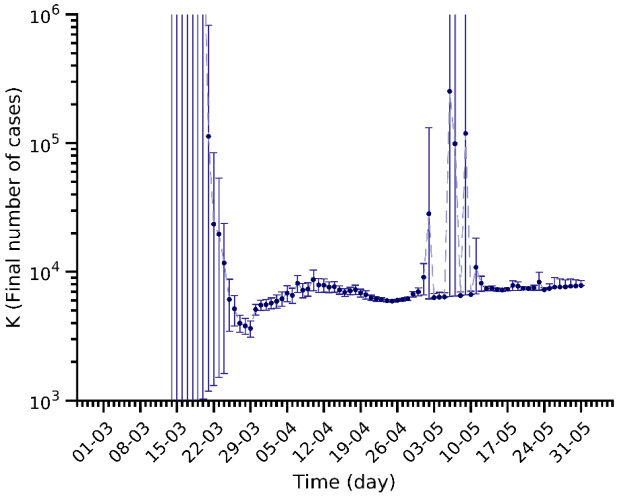


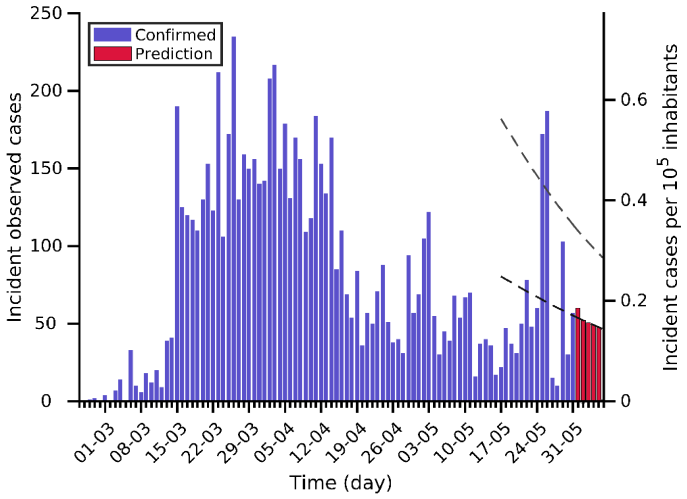
Malaysia 31-05-2020. Population: 32.4M. Current cumulated incidence: 24/10^5

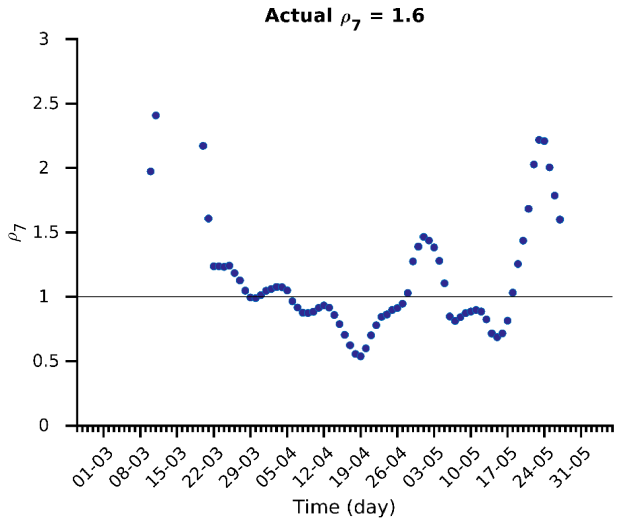


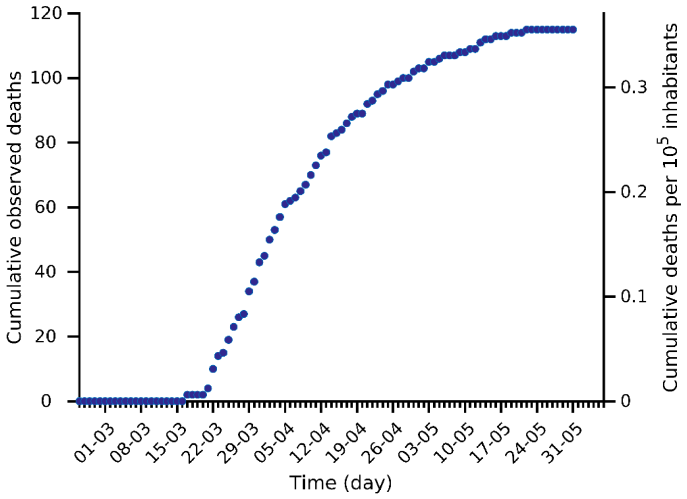


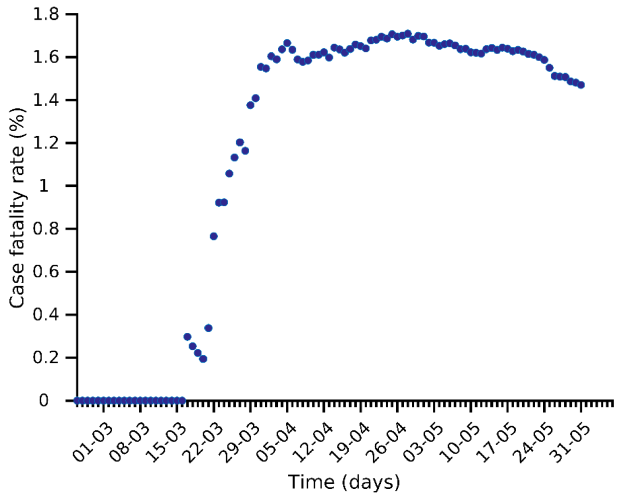




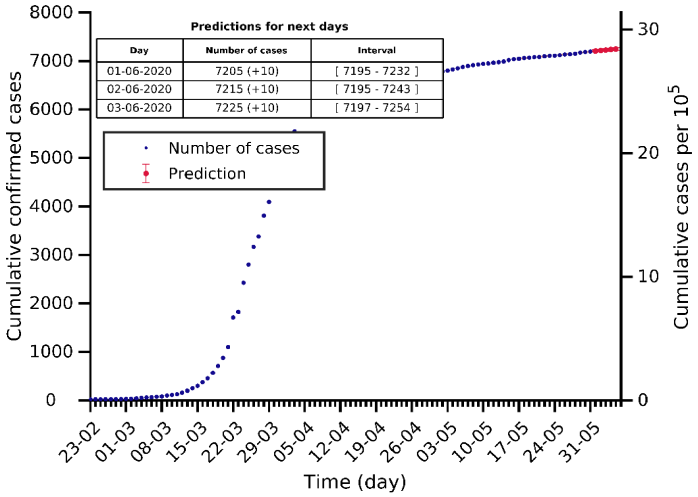


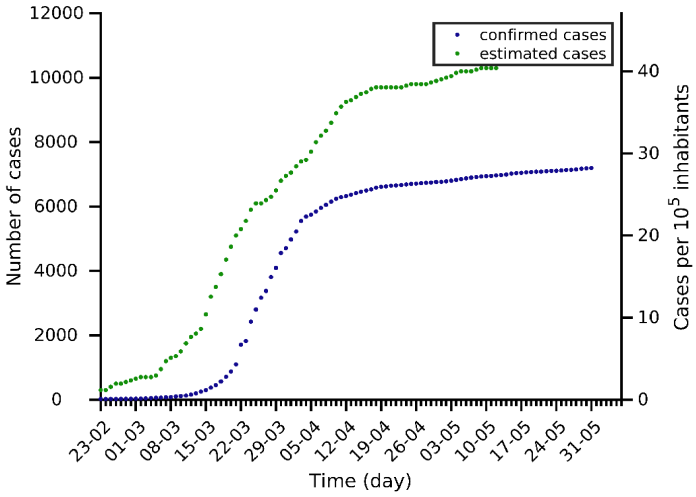


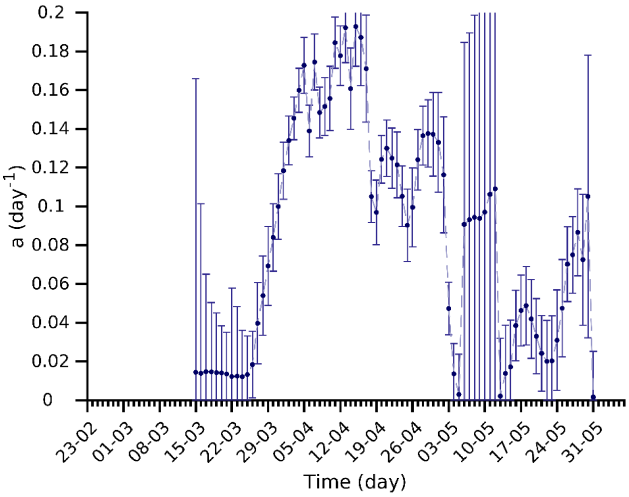


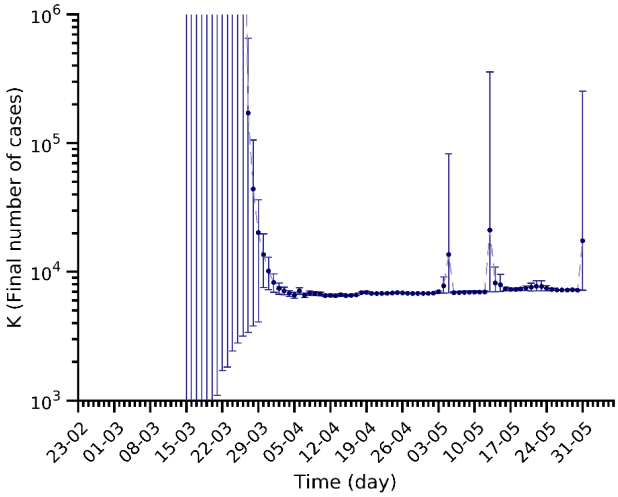


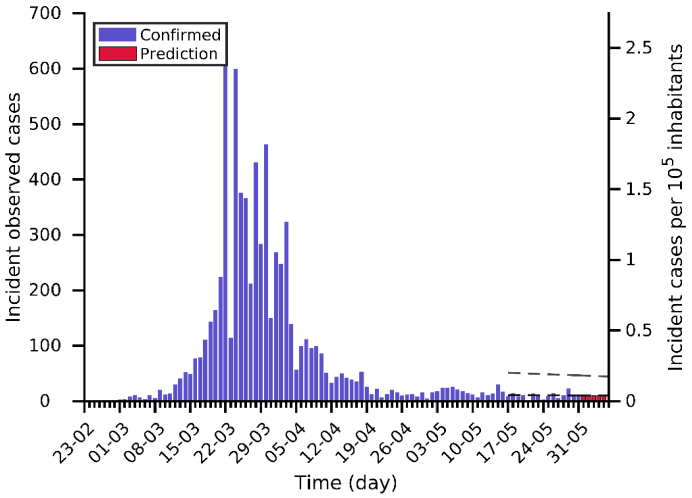
Australia 31-05-2020. Population: 25.5M. Current cumulated incidence: $28/10^5$

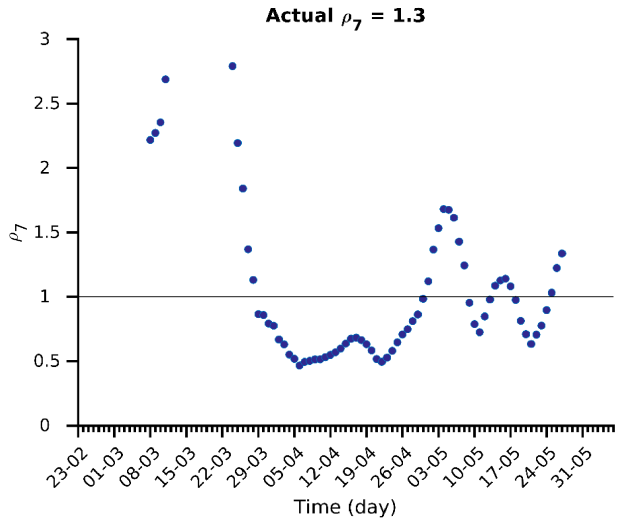


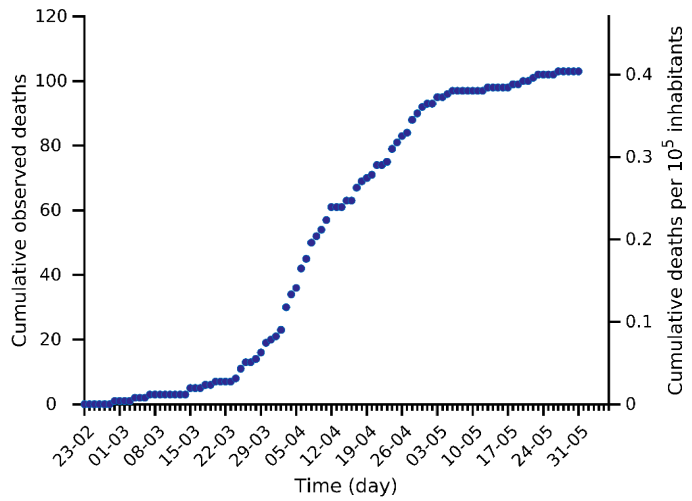


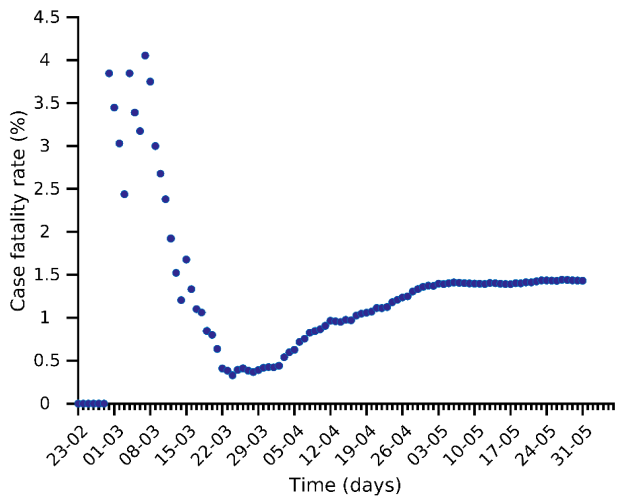




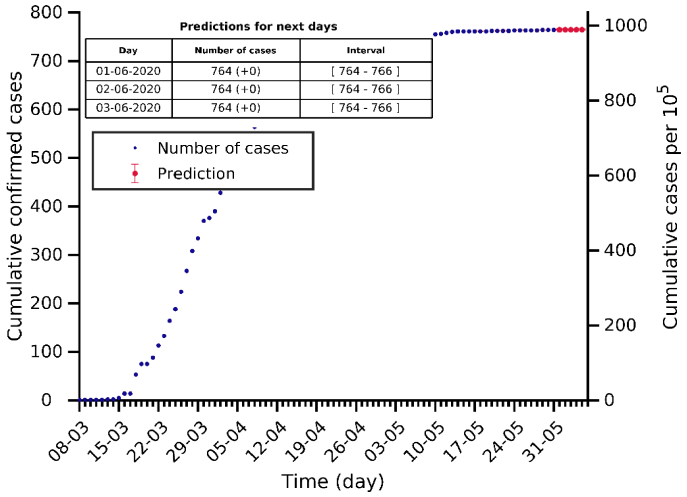


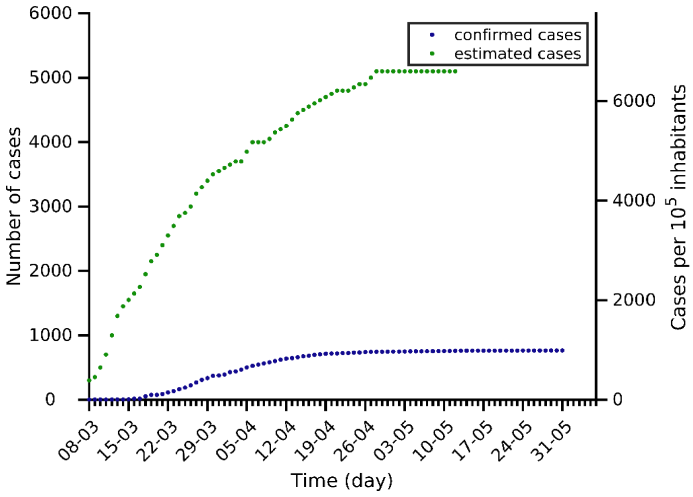


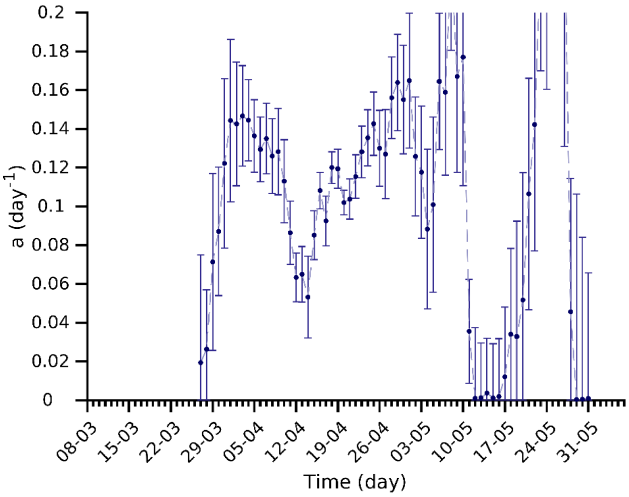


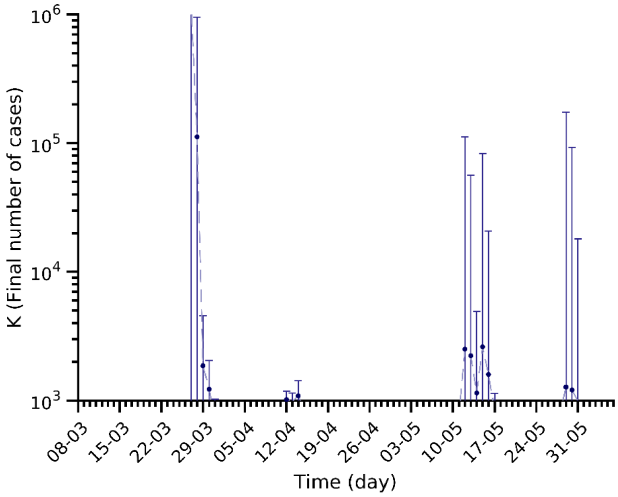


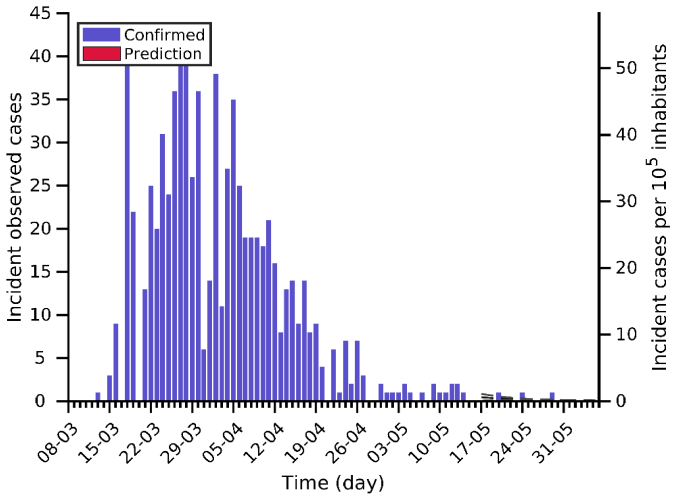
Andorra 31-05-2020. Population: 0.1M. Current cumulated incidence: 989/10^5

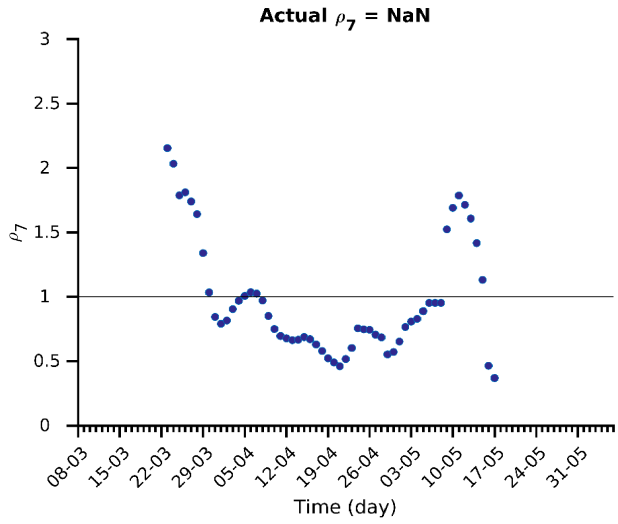


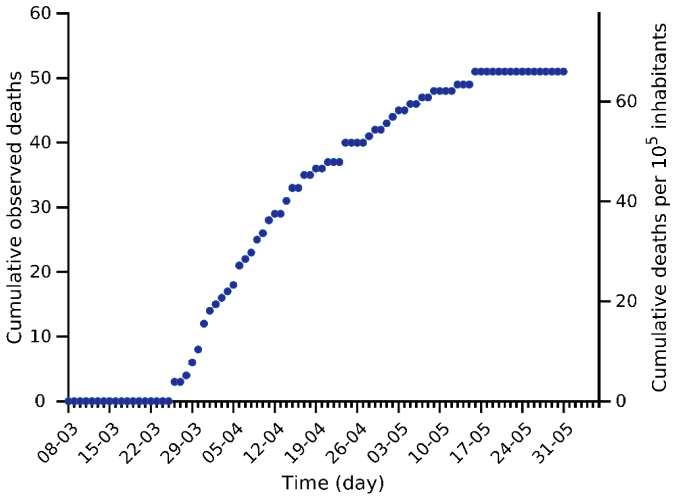


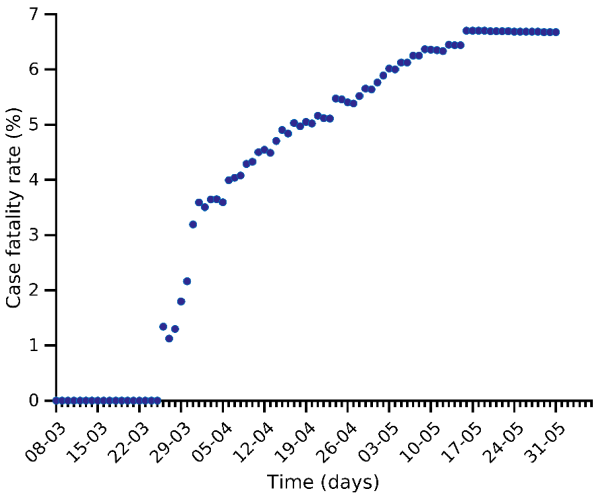








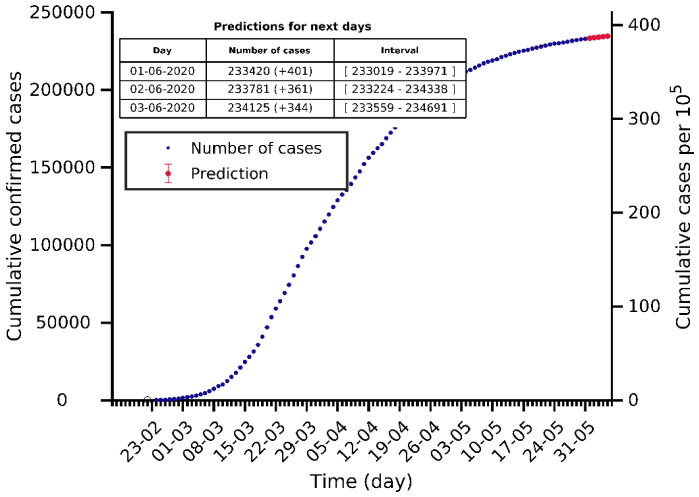


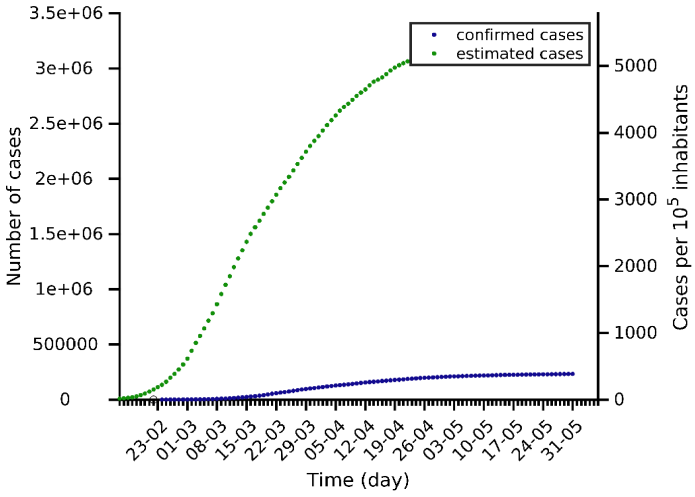


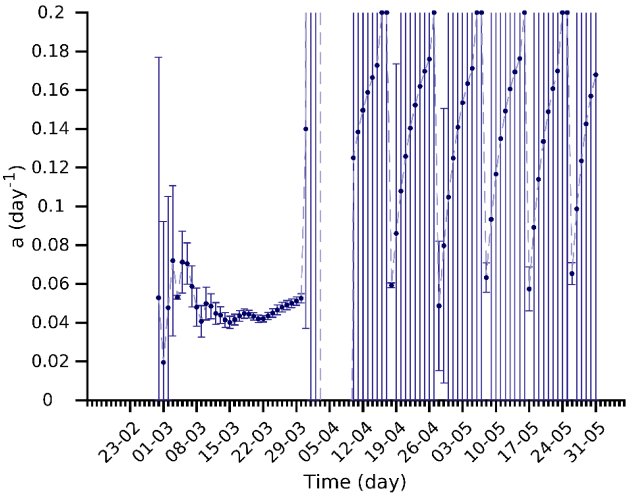
(3) Analysis and prediction of COVID-19 for Italy and its regions

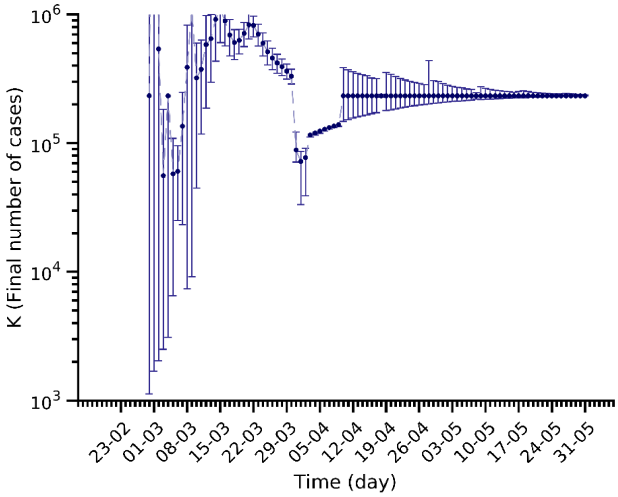
Data obtained from: https://github.com/pcm-dpc/COVID-19/tree/master/dati-andamento-nazionale

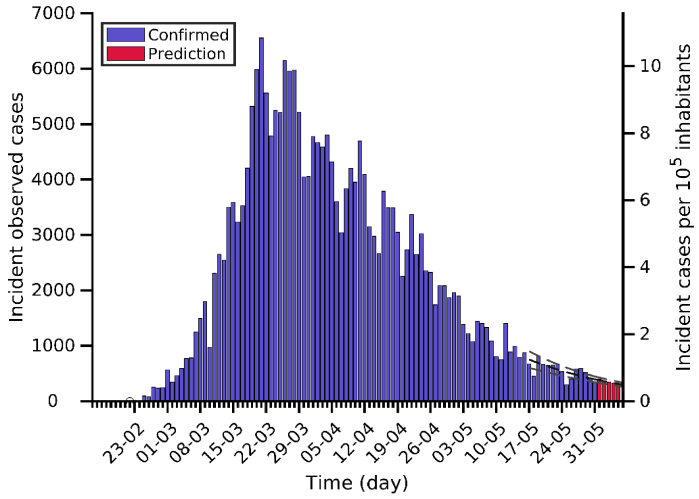
Italy 31-05-2020. Population: 60.5M. Current cumulated incidence: $385/10^5$

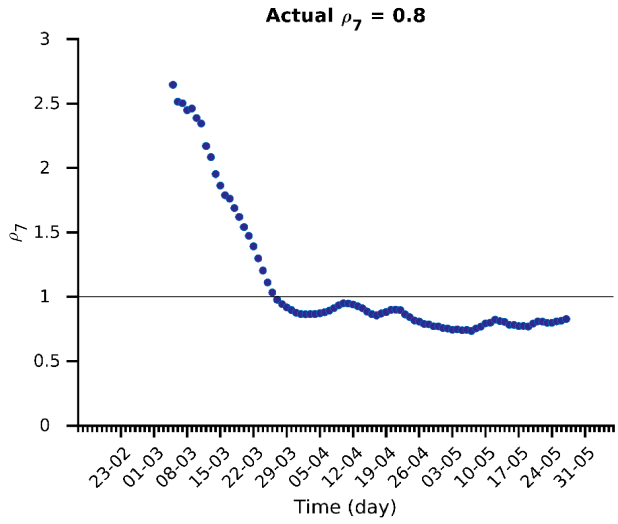


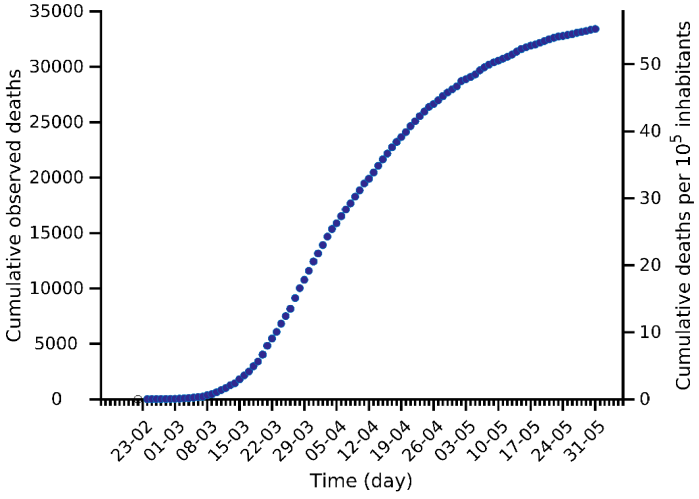


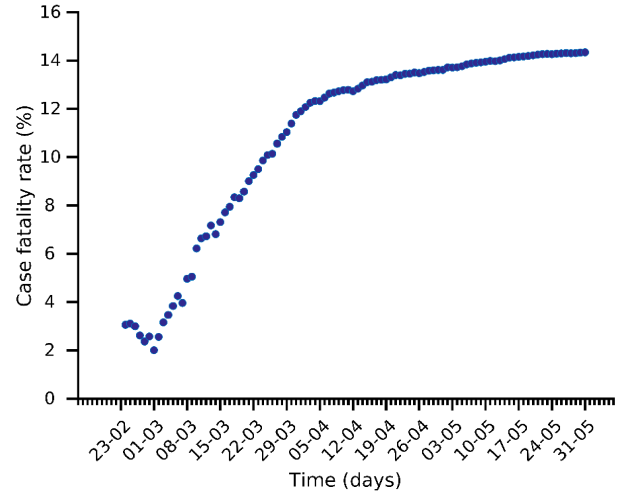




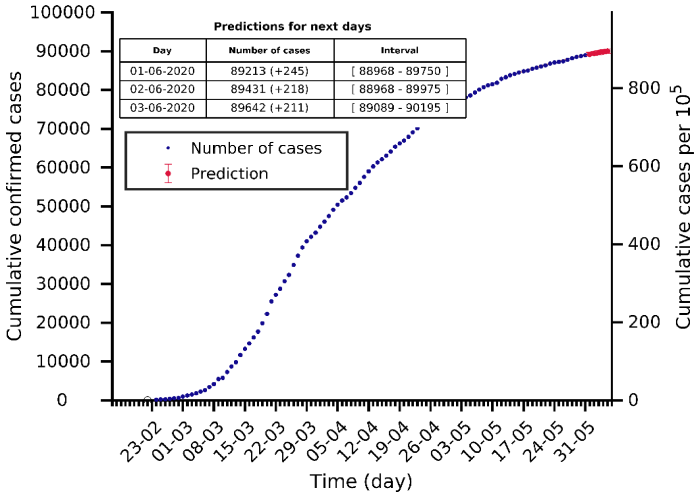


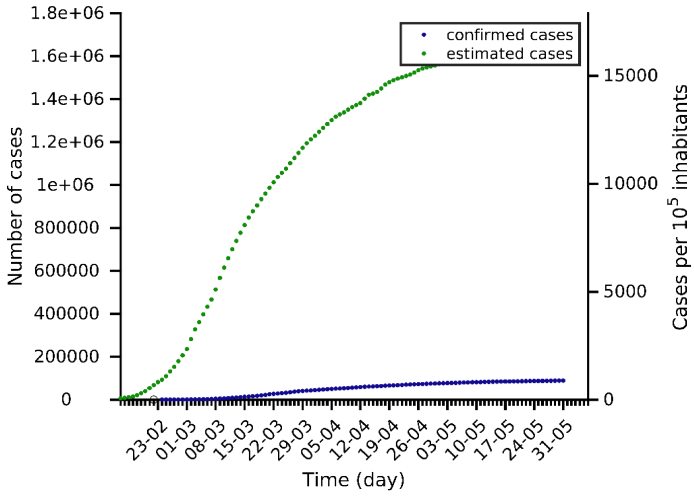


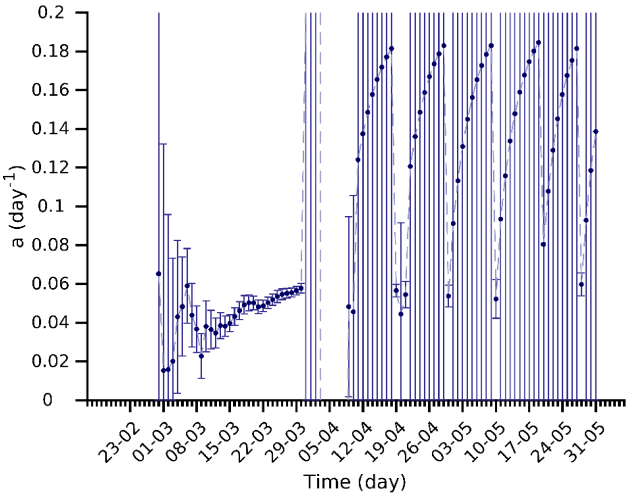


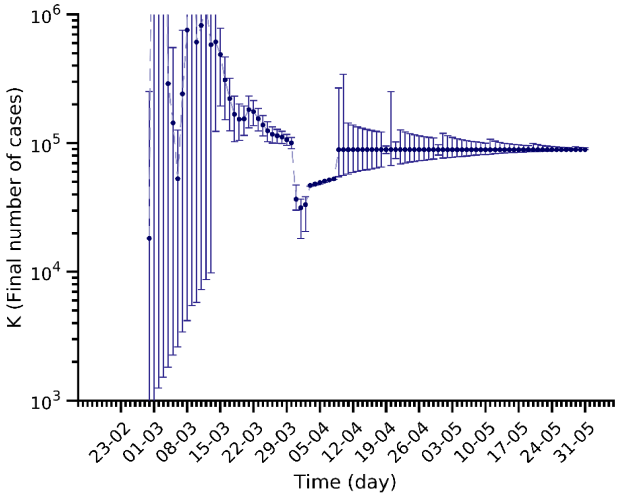


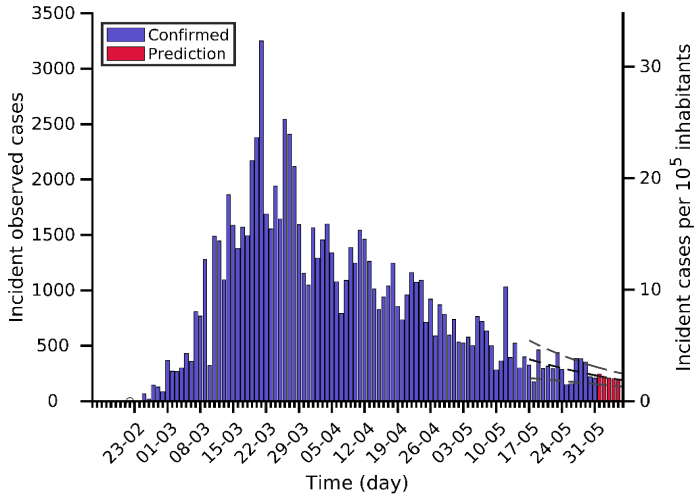
Lombardia 31-05-2020. Population: 10.1M. Current cumulated incidence: $884/10^5$

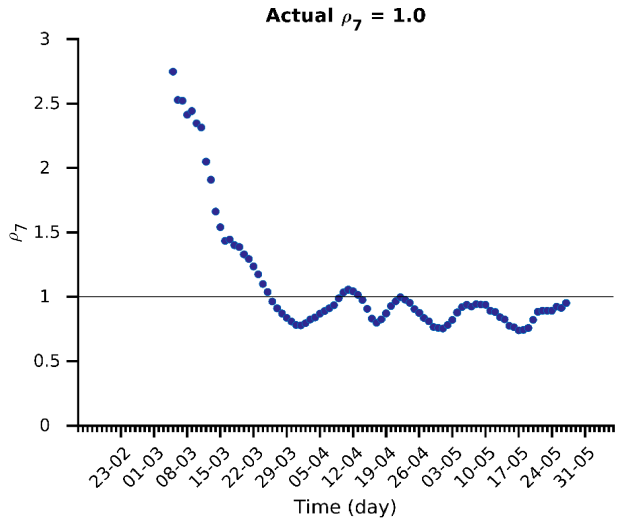


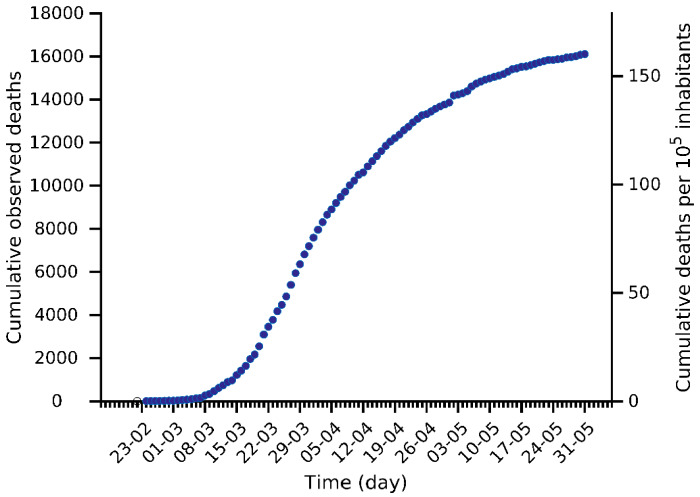


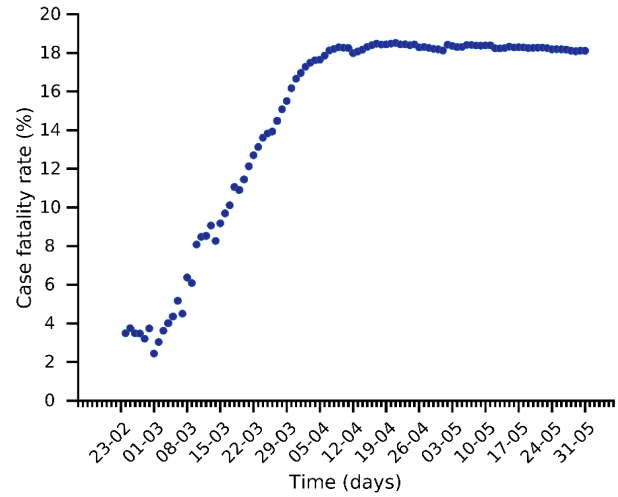




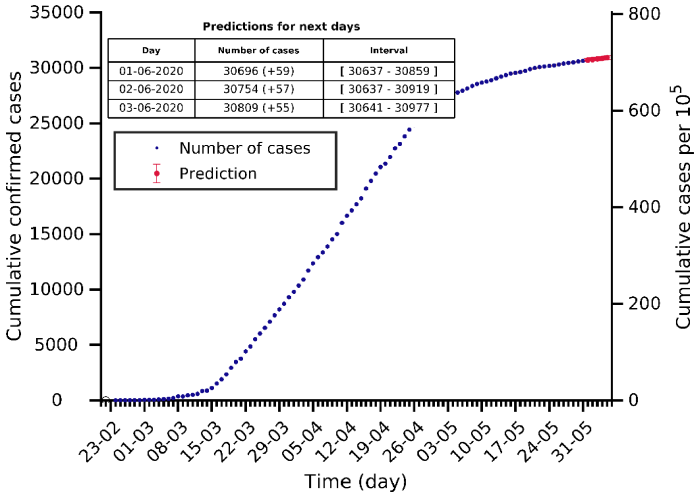


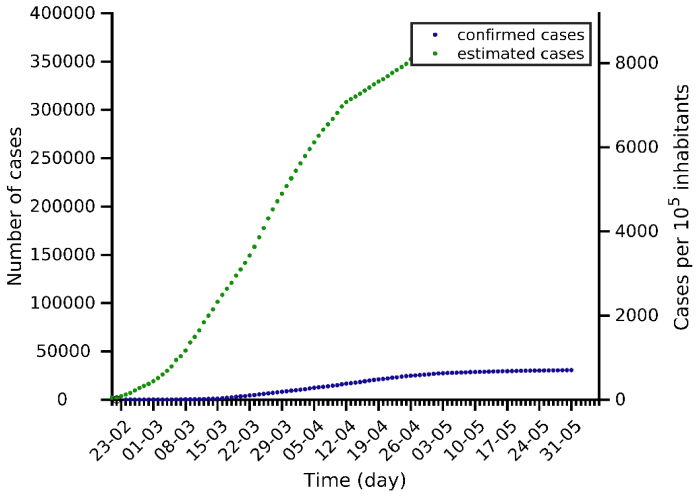


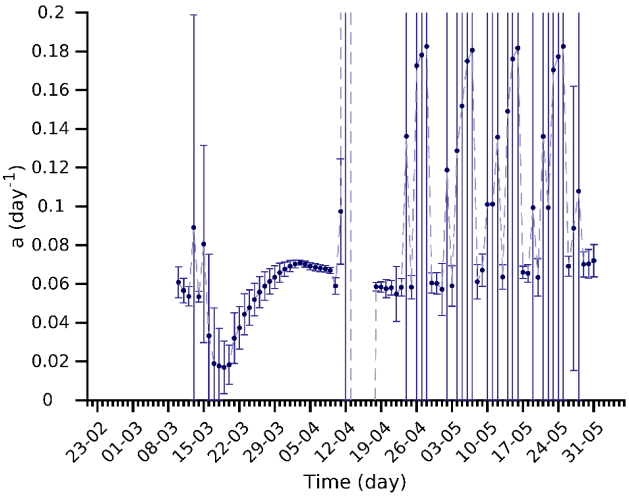


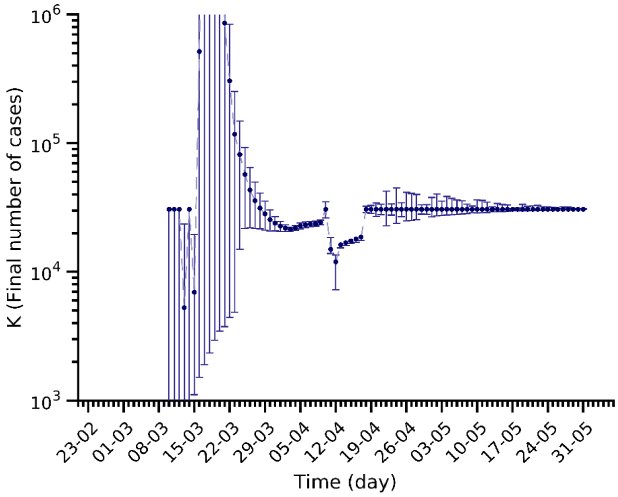


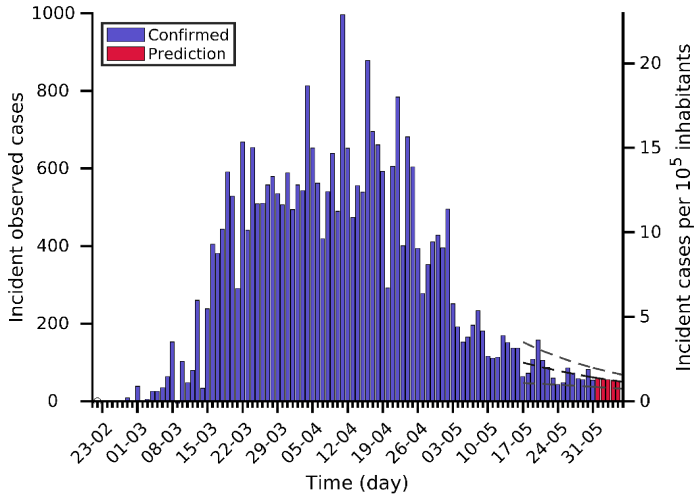
Piemonte 31-05-2020. Population: 4.4M. Current cumulated incidence: 703/10⁵

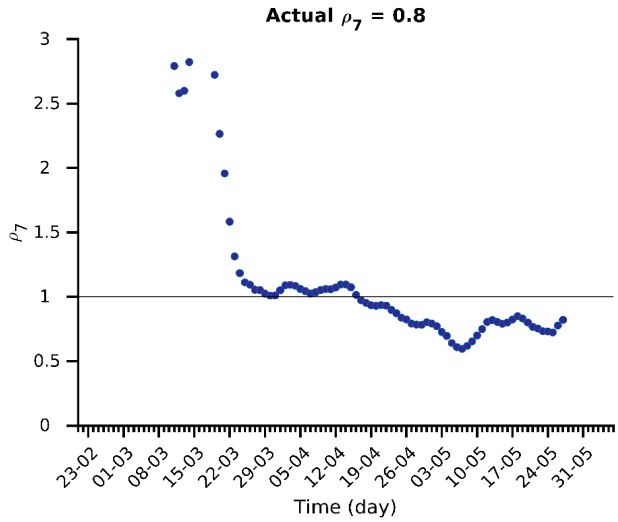


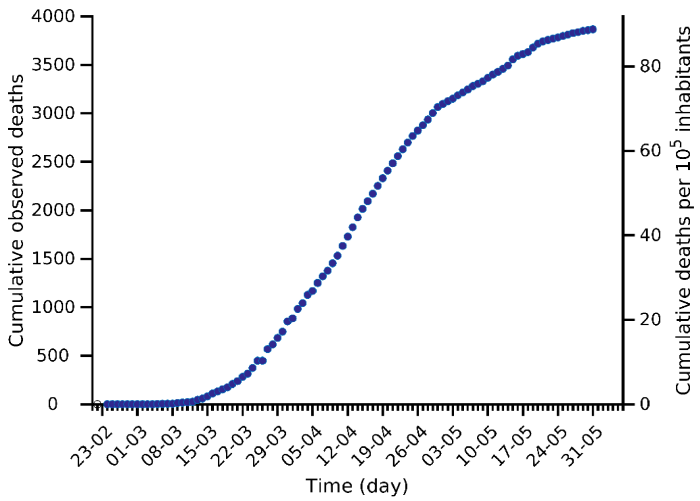


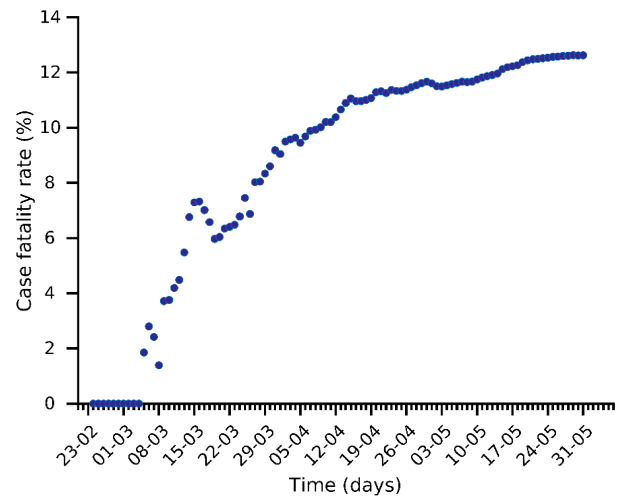




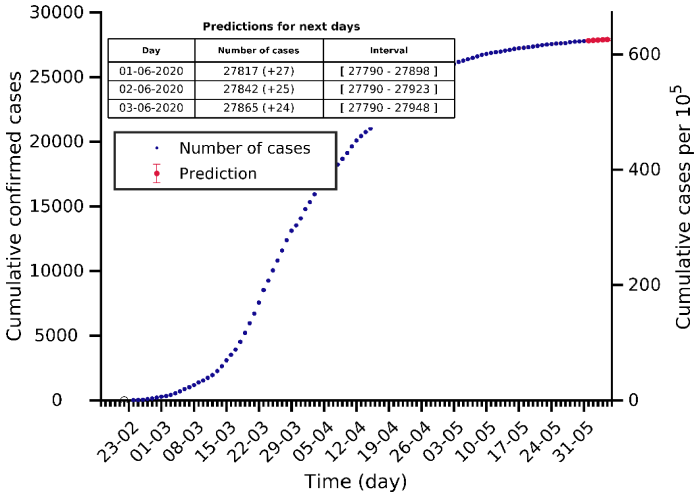


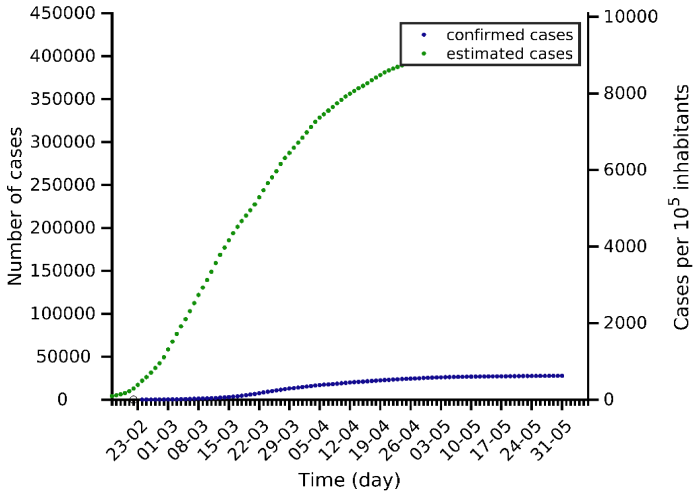


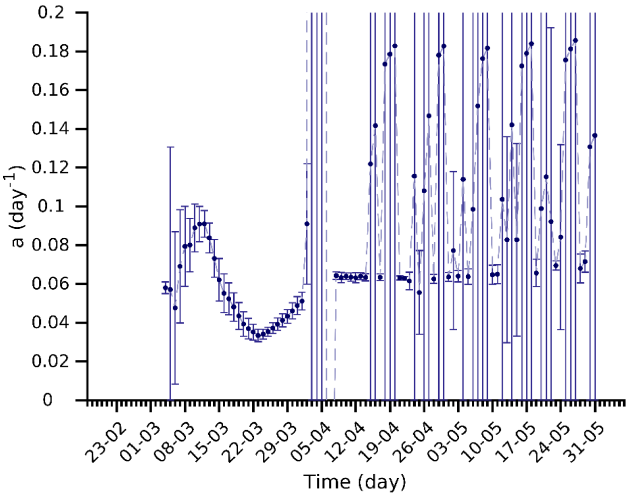


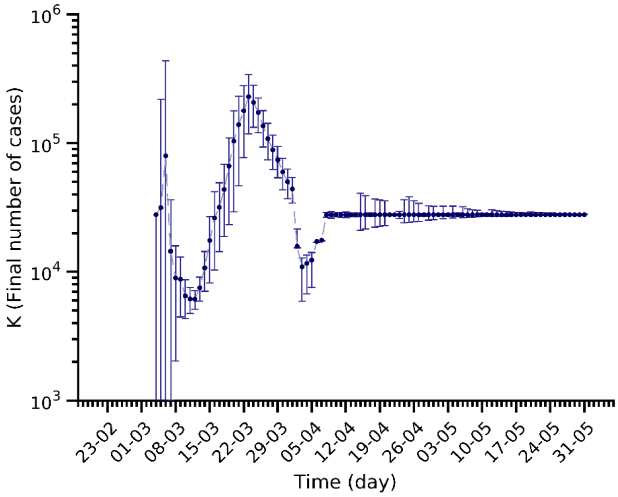


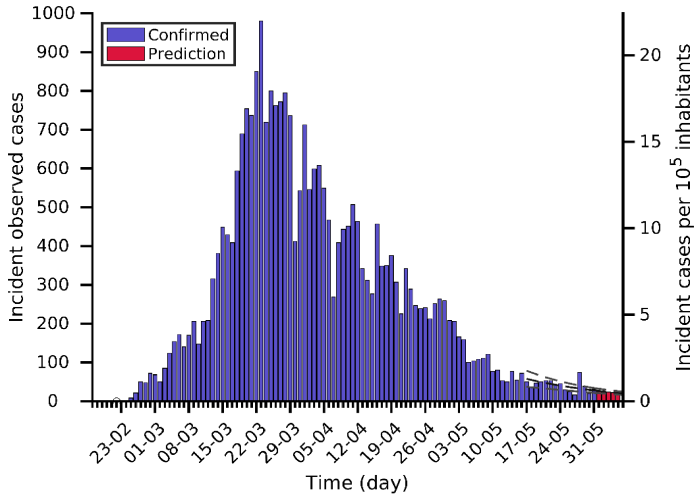
Emilia Romagna 31-05-2020. Population: 4.5M. Current cumulated incidence: 623/1

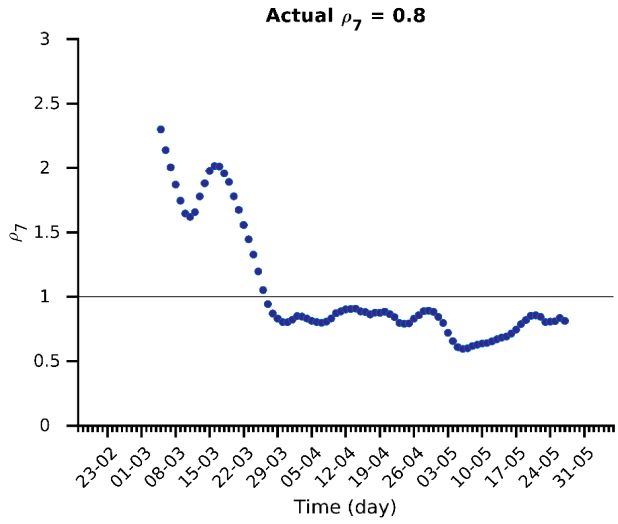


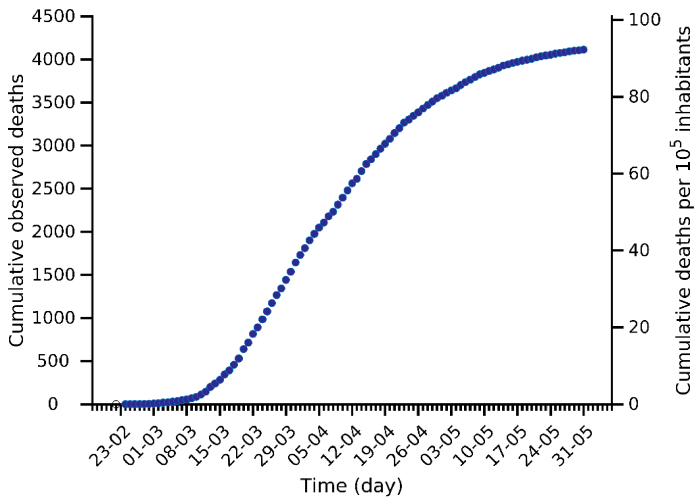


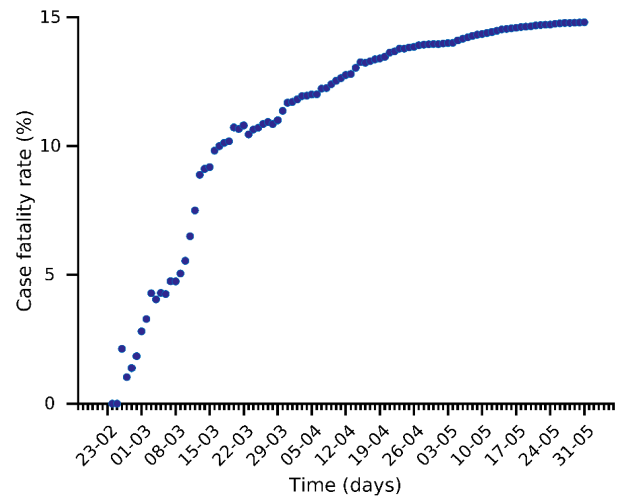




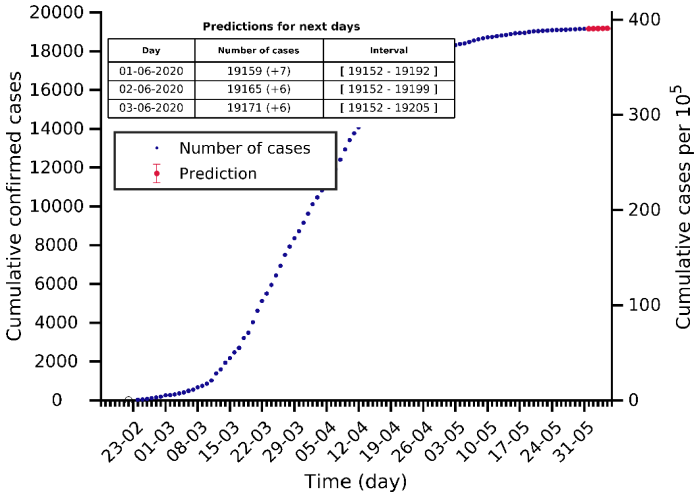


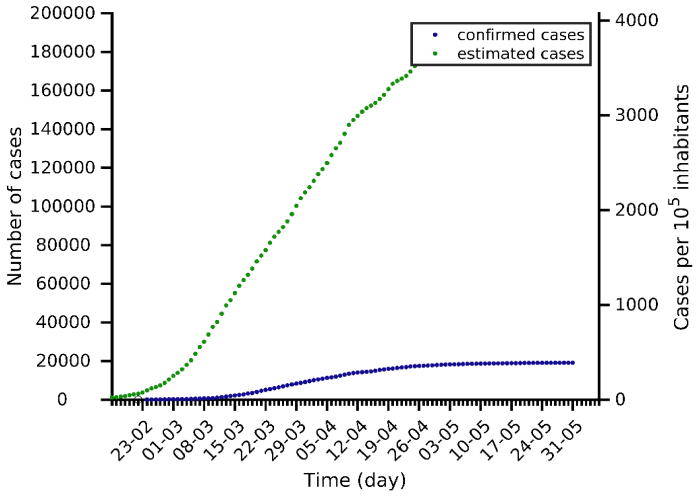


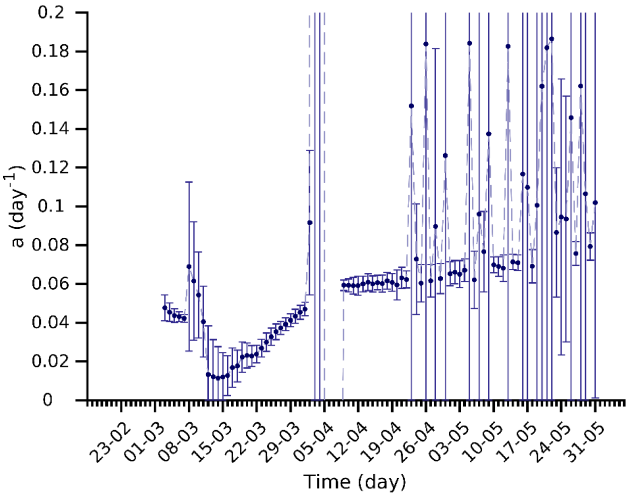


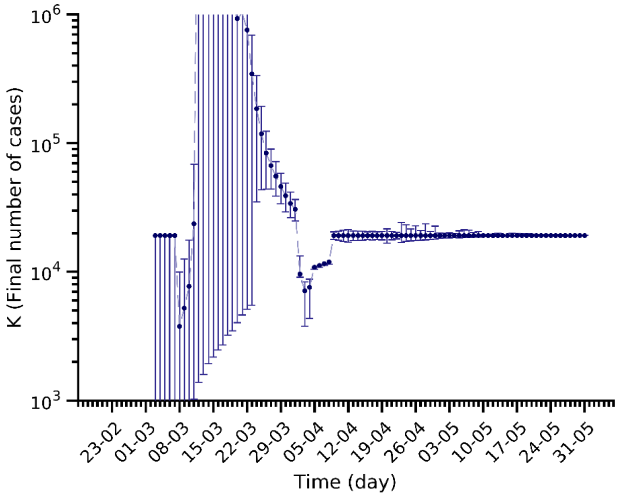


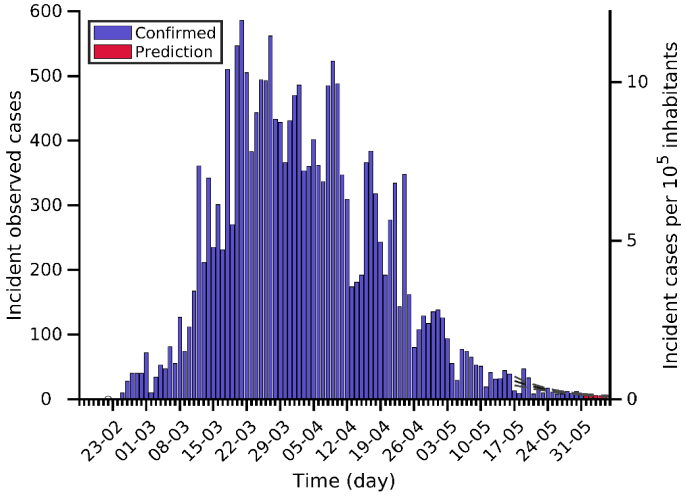
Veneto 31-05-2020. Population: 4.9M. Current cumulated incidence: 390/10⁵

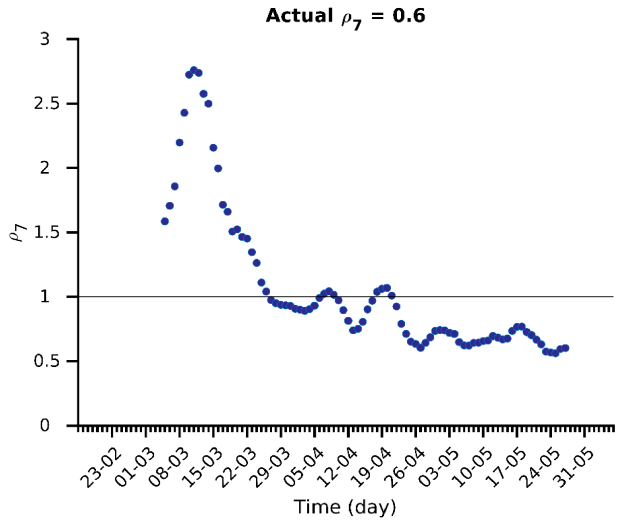


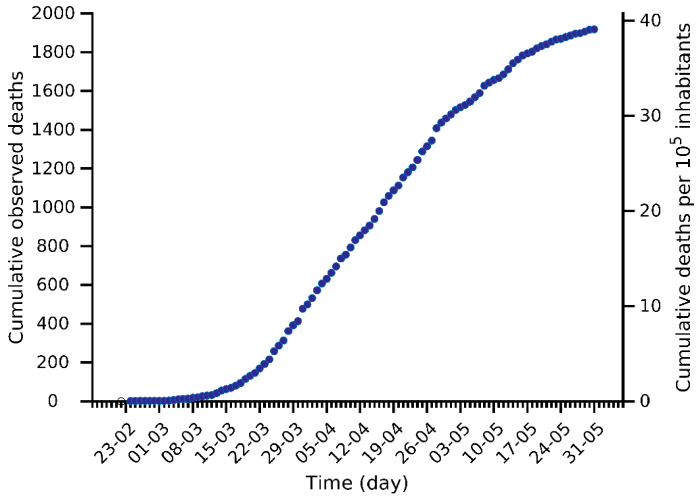


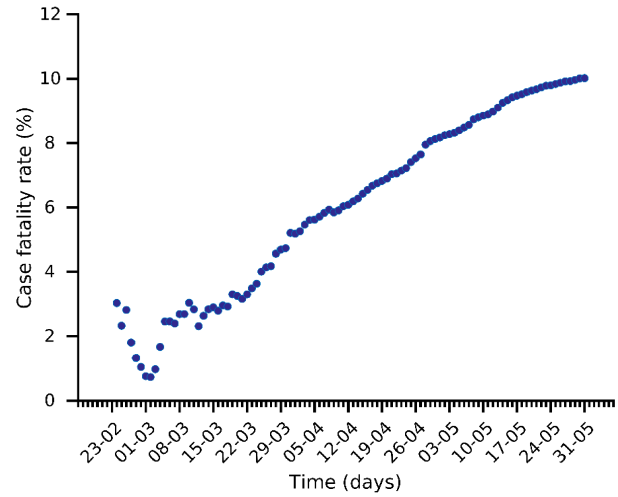




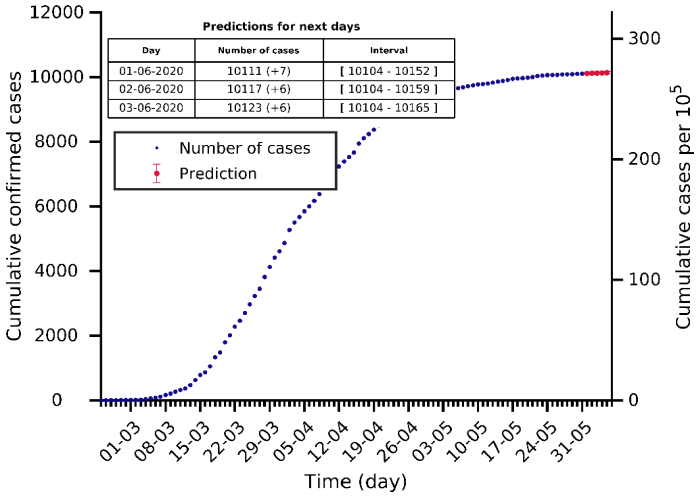


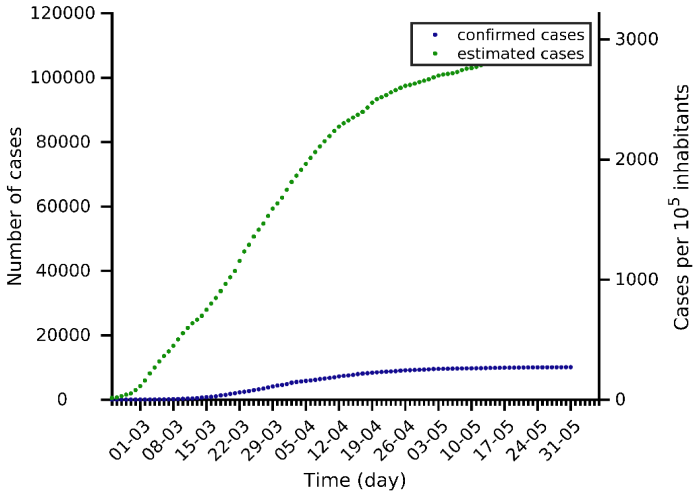


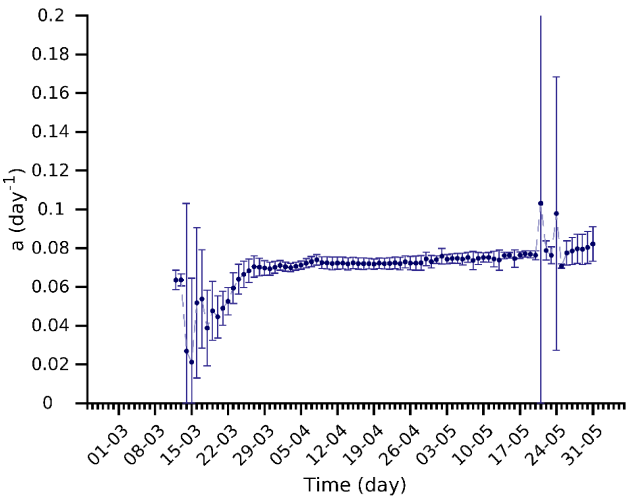


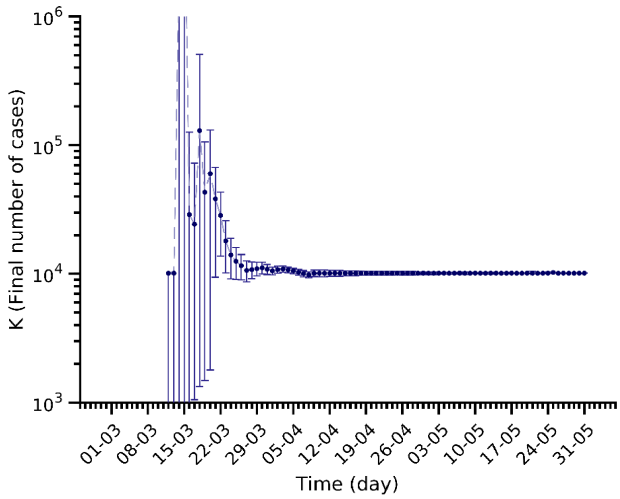


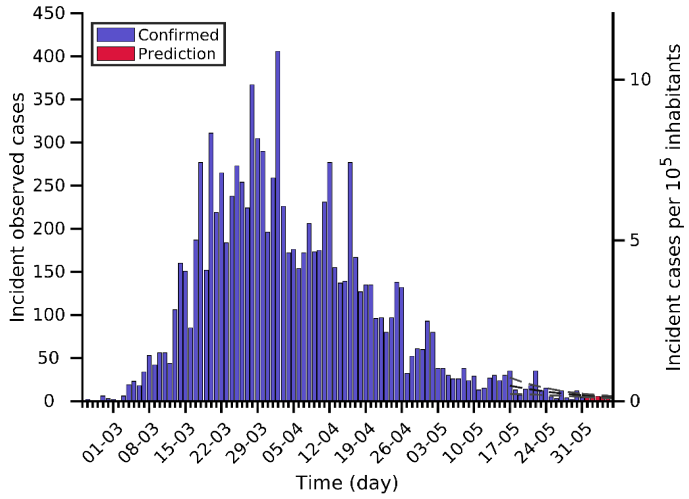
Toscana 31-05-2020. Population: 3.7M. Current cumulated incidence: 271/10^5

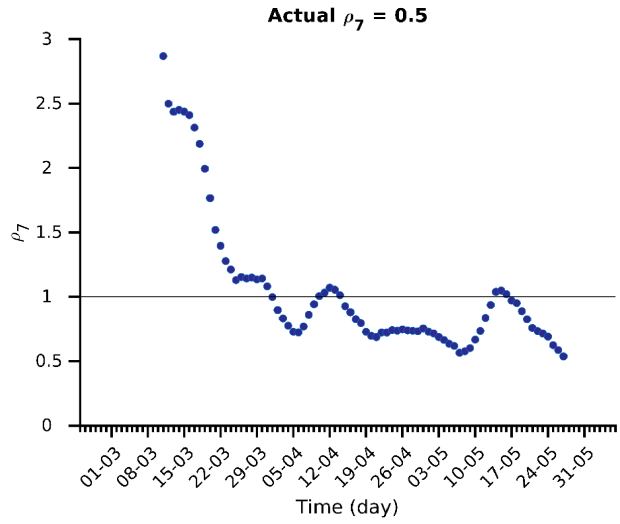


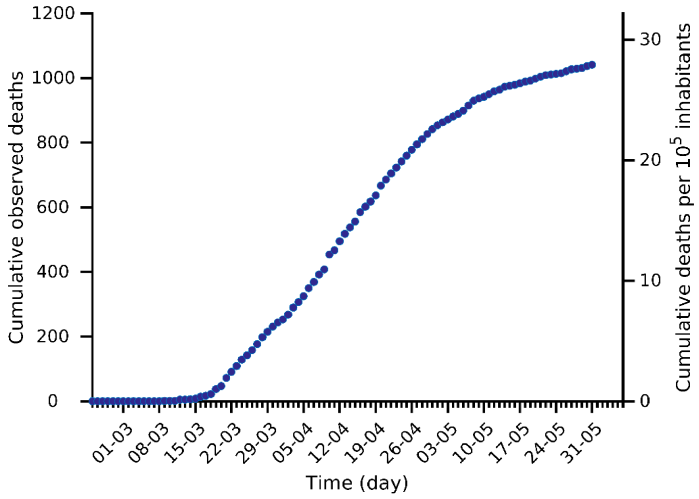


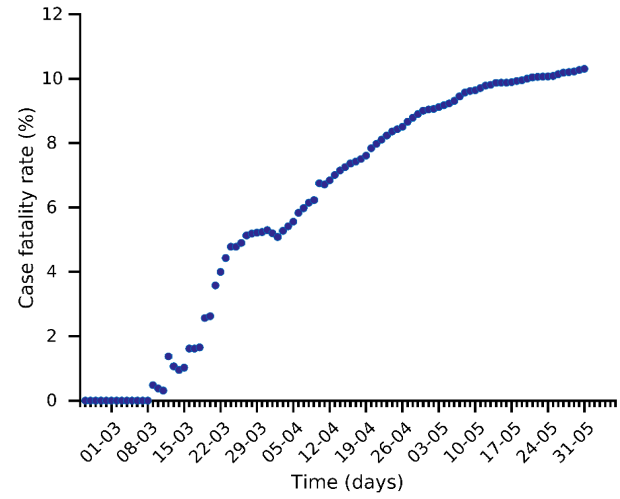




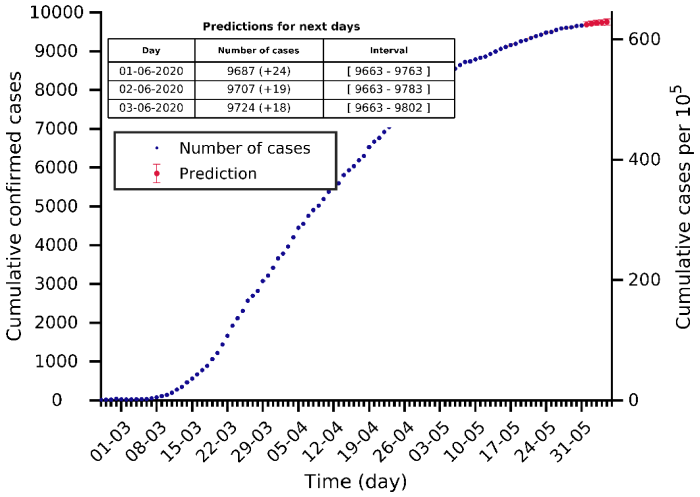


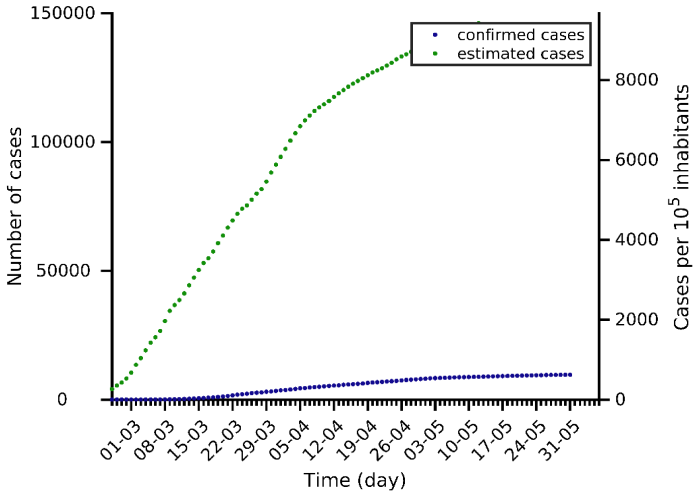


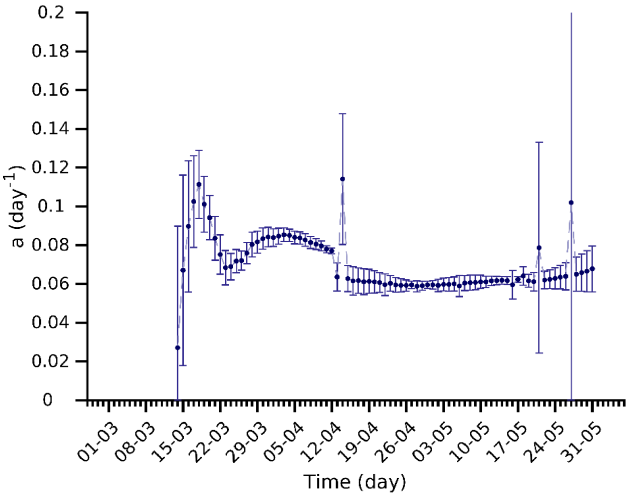


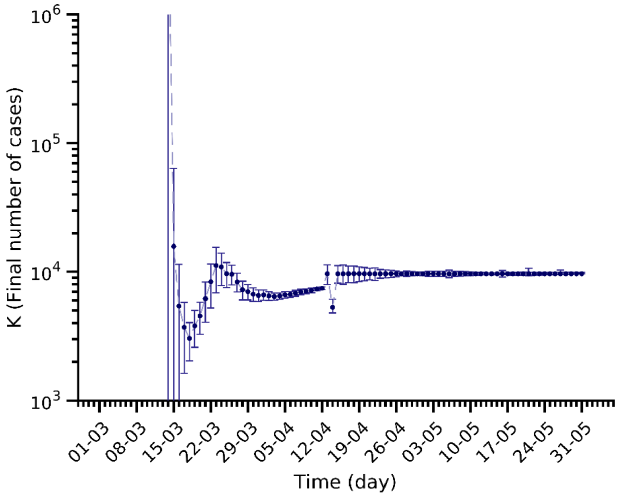


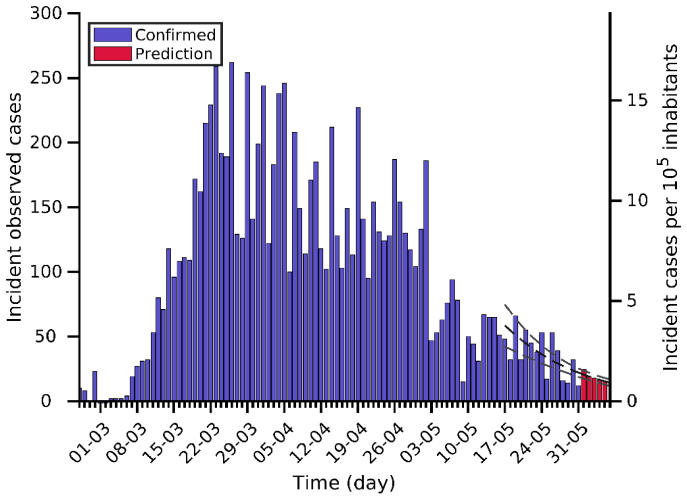
Liguria 31-05-2020. Population: 1.6M. Current cumulated incidence: 623/10^5

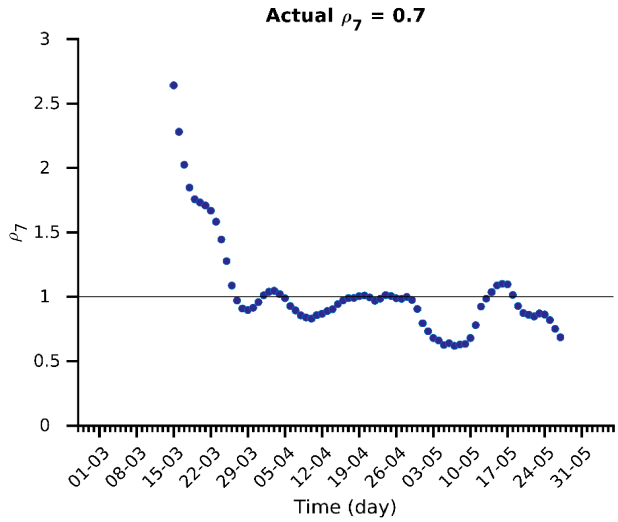


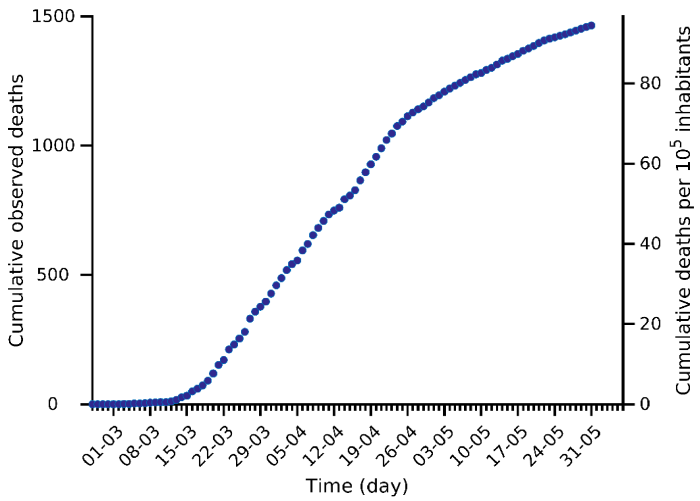


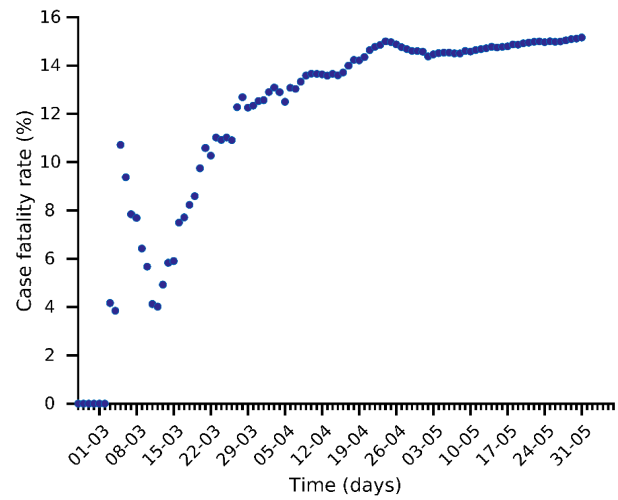




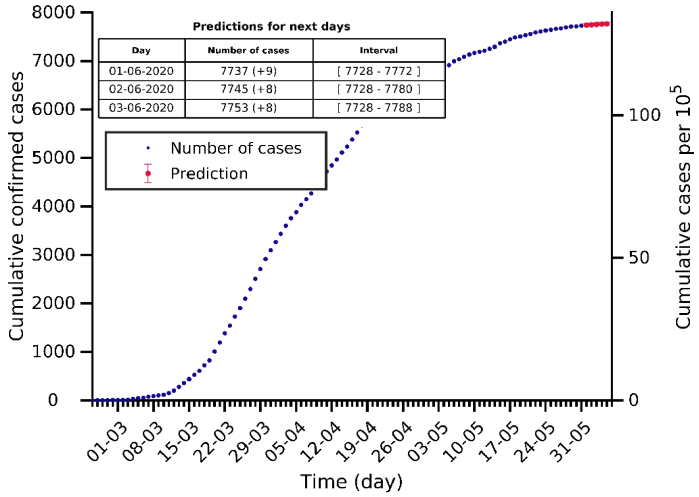


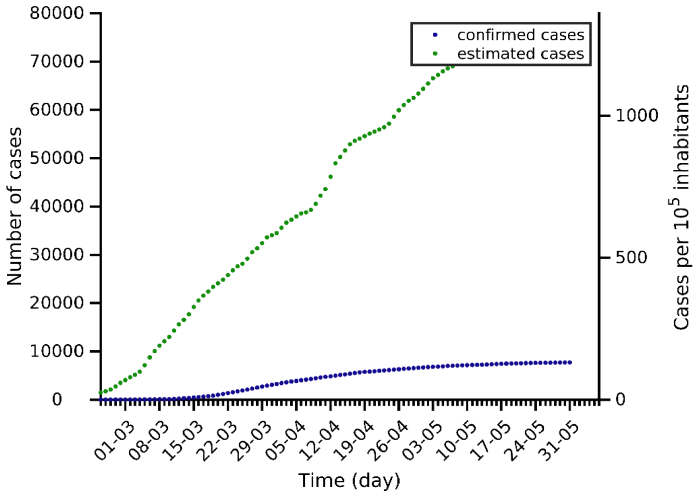


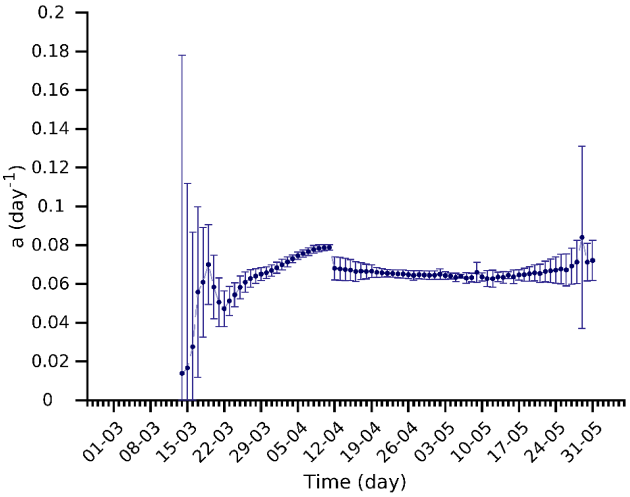


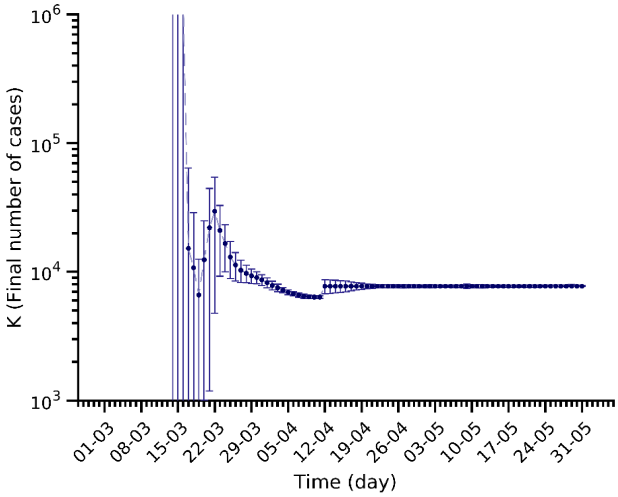


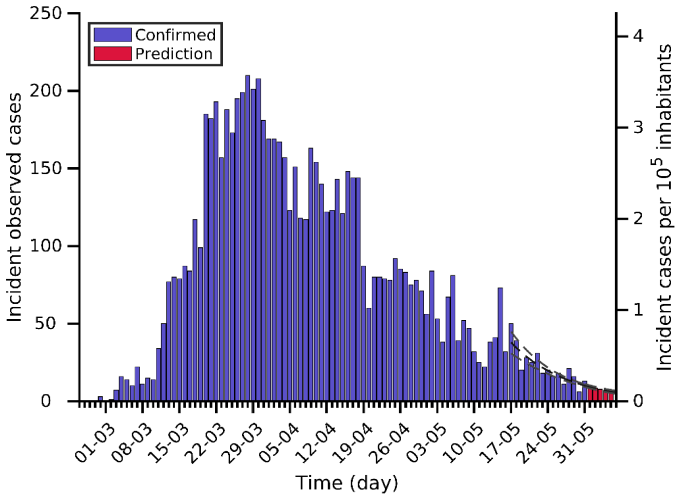
Lazio 31-05-2020. Population: 5.9M. Current cumulated incidence: 131/10⁵

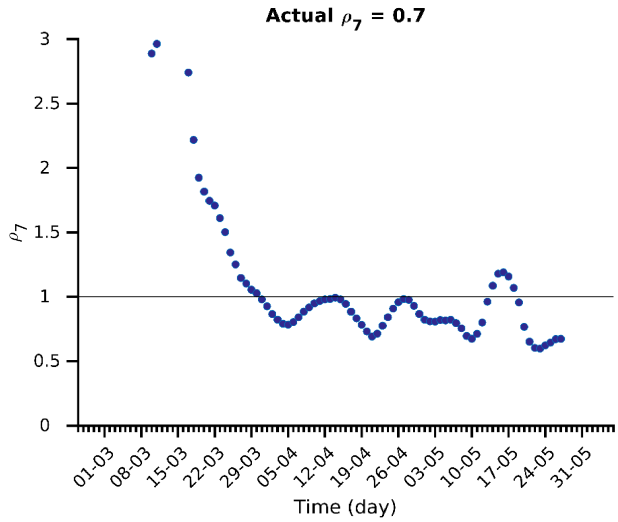


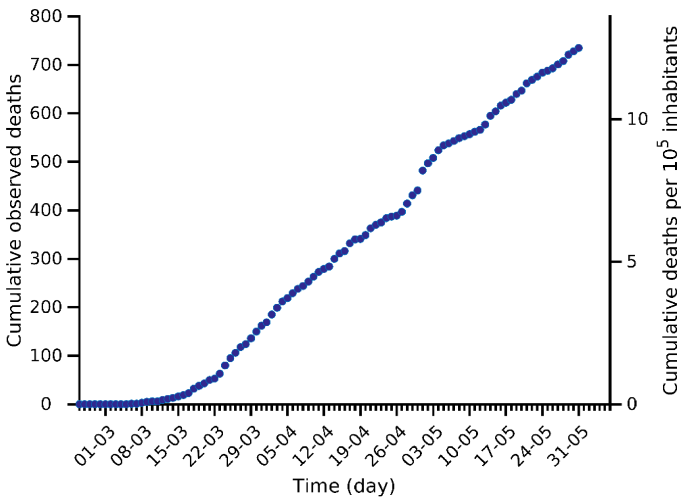


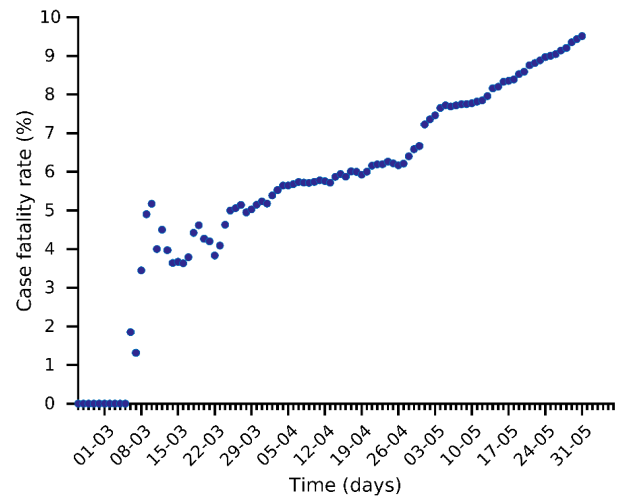




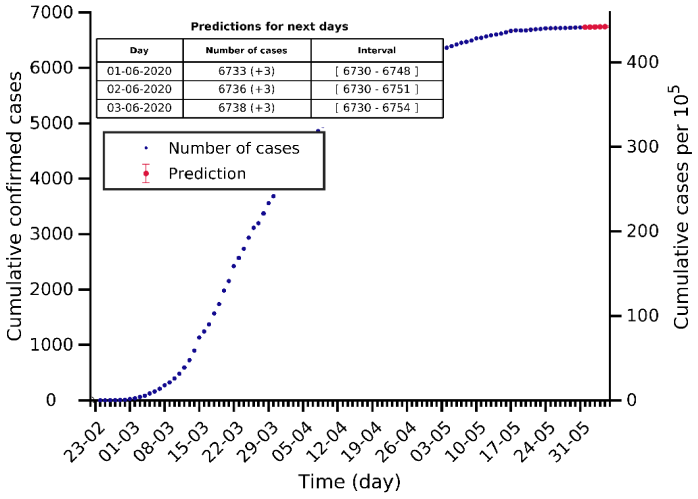


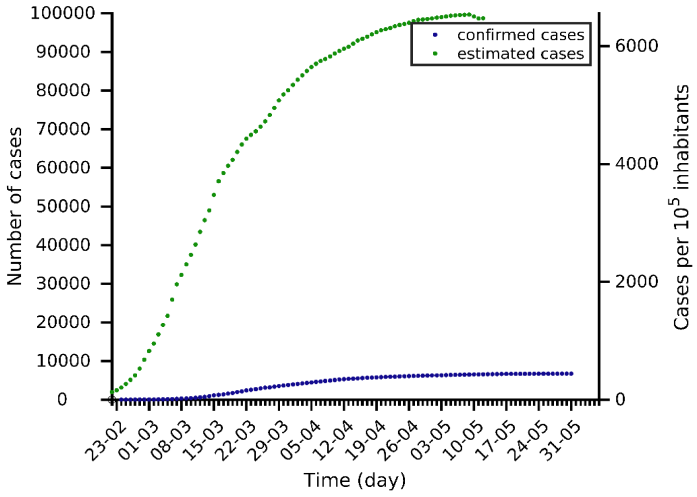


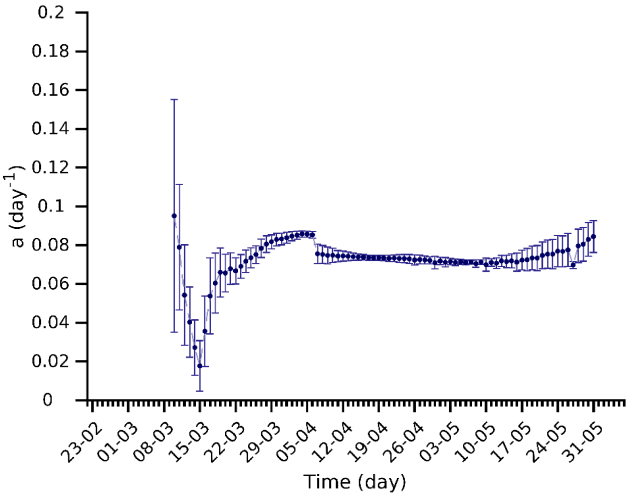


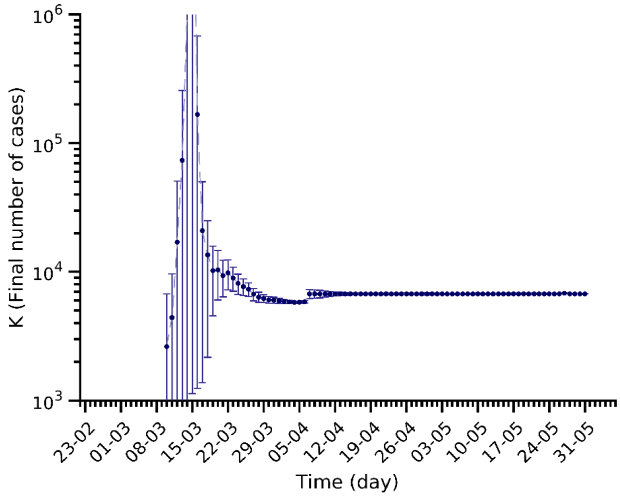


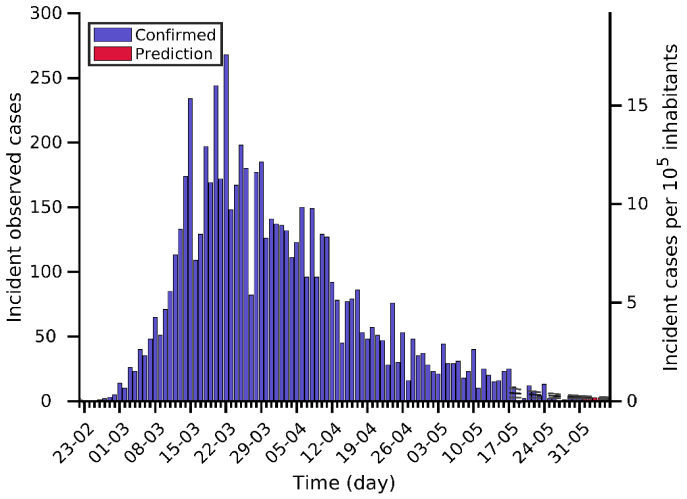
Marche 31-05-2020. Population: 1.5M. Current cumulated incidence: 441/10⁵

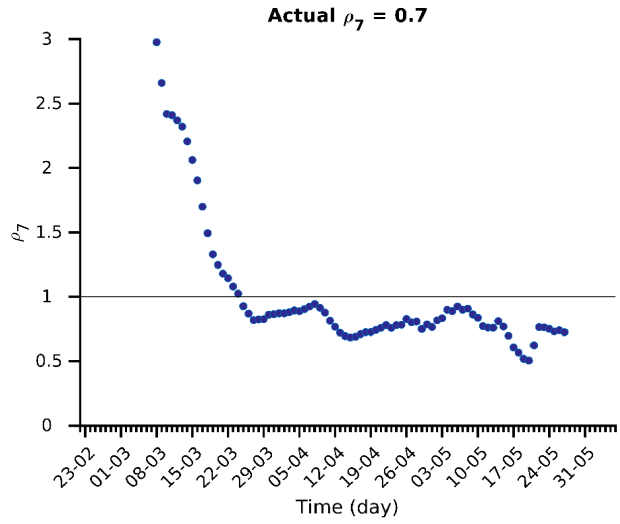


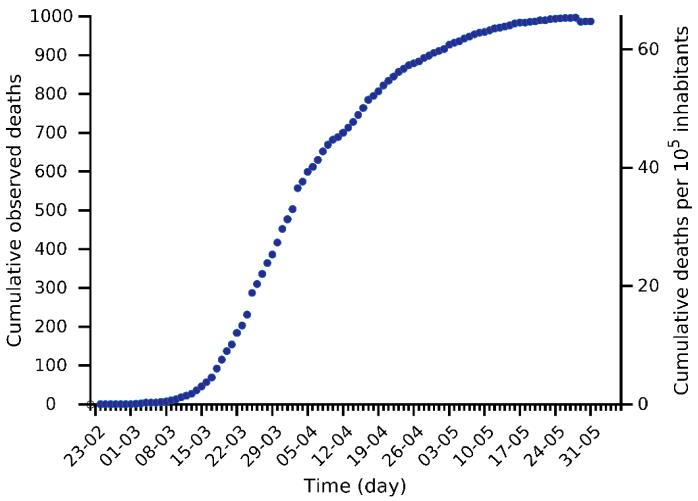


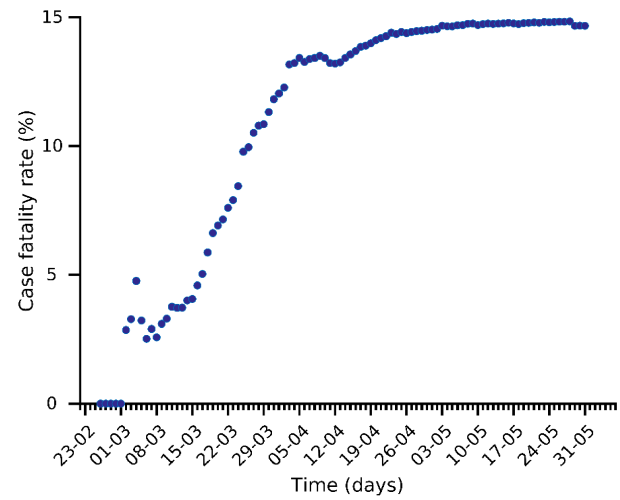




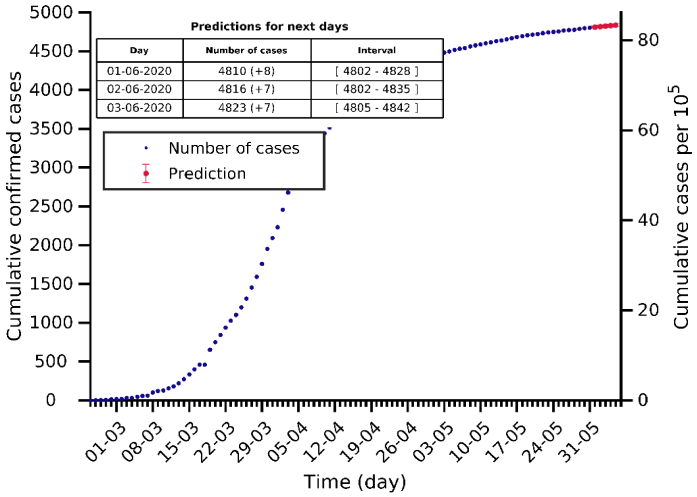


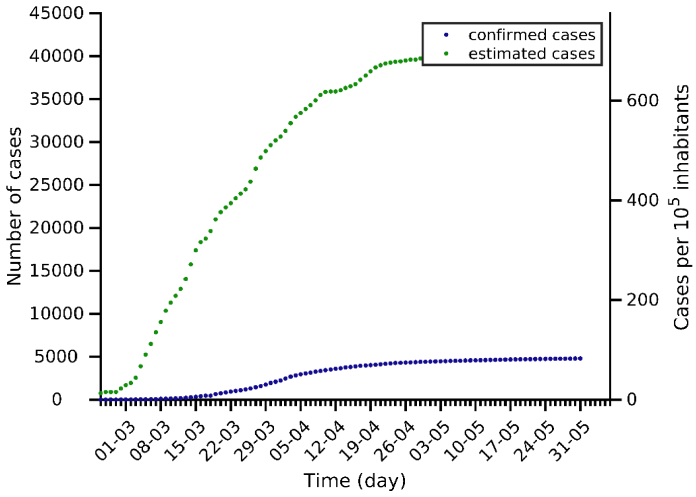


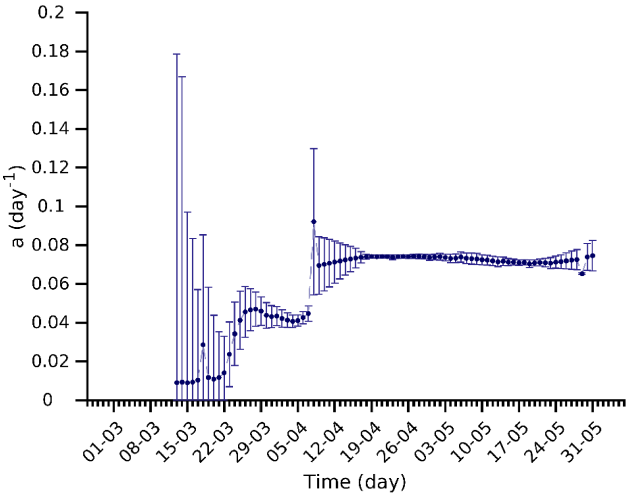


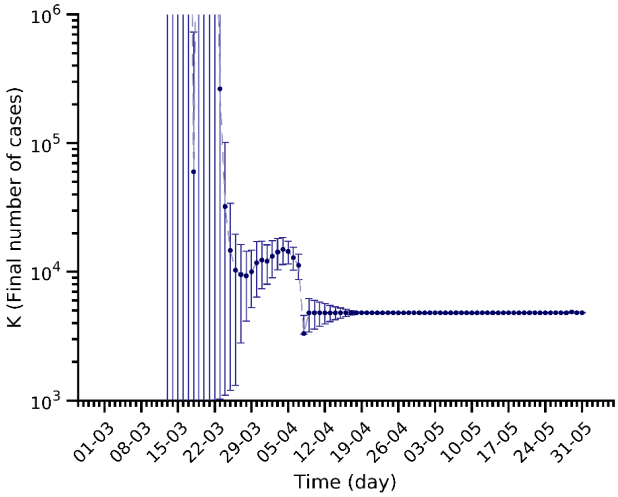


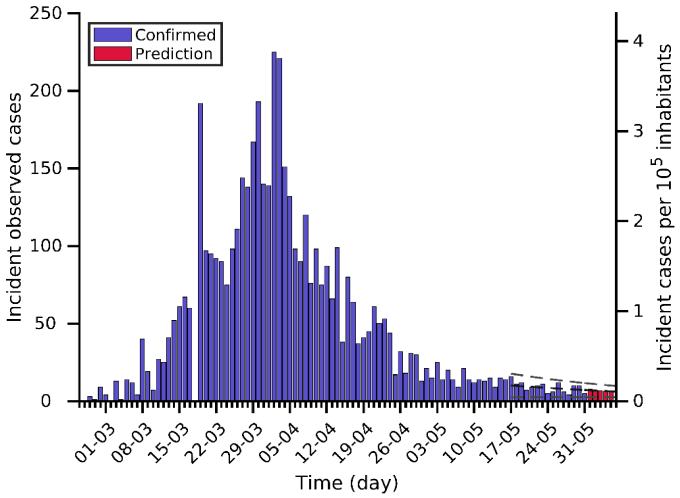
Campania 31-05-2020. Population: 5.8M. Current cumulated incidence: 83/10^5

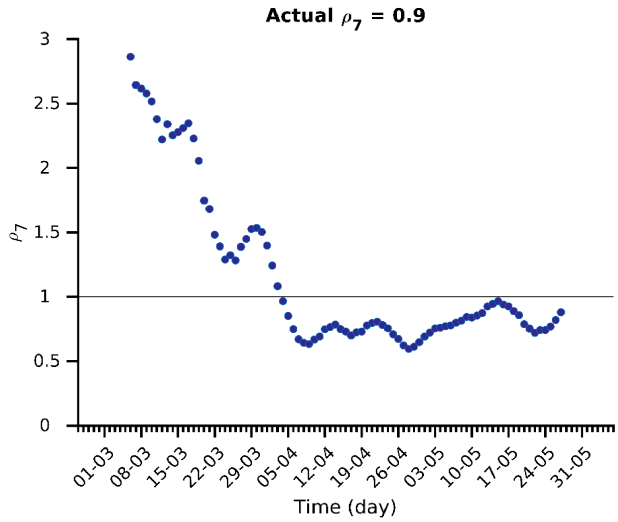


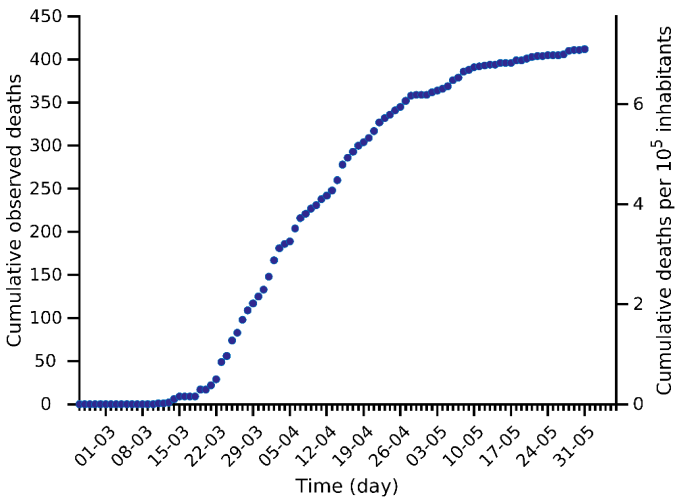


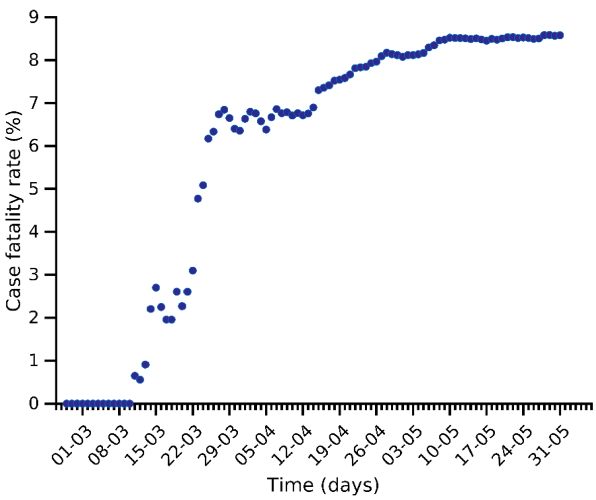




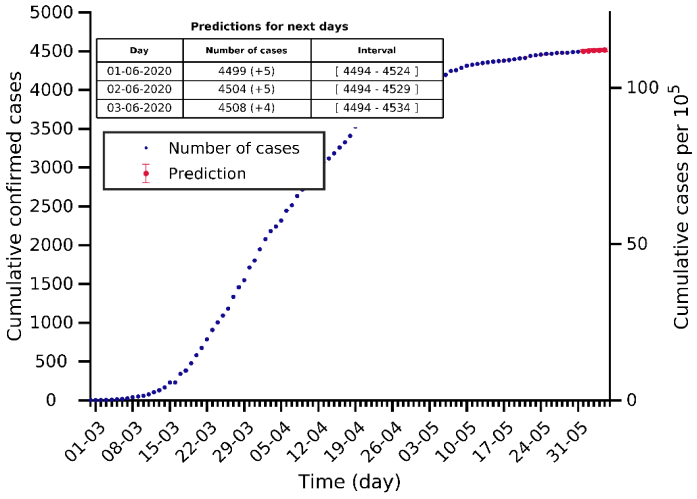


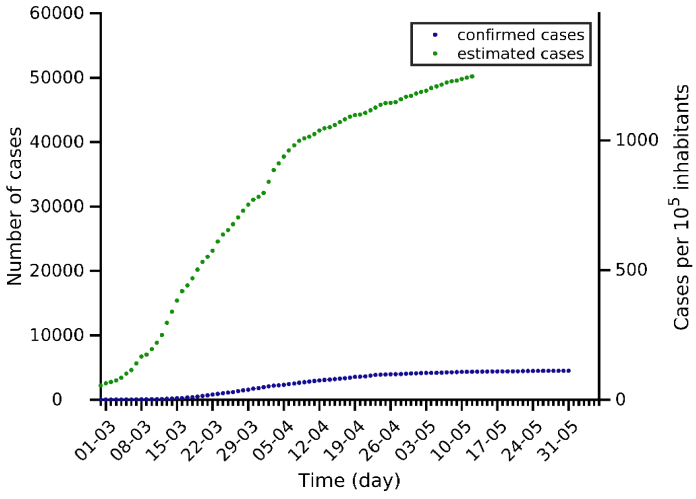


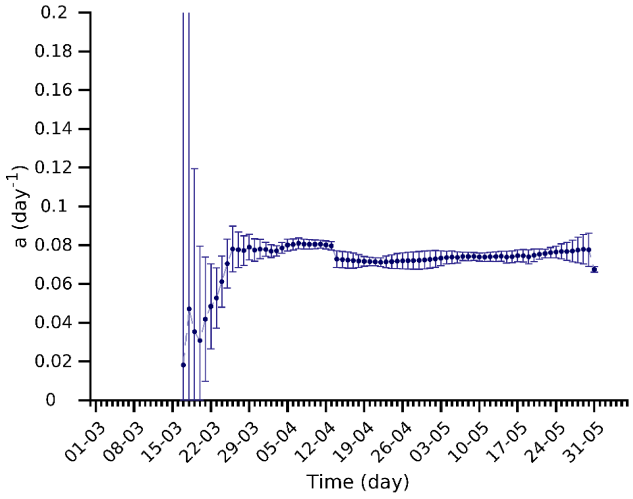


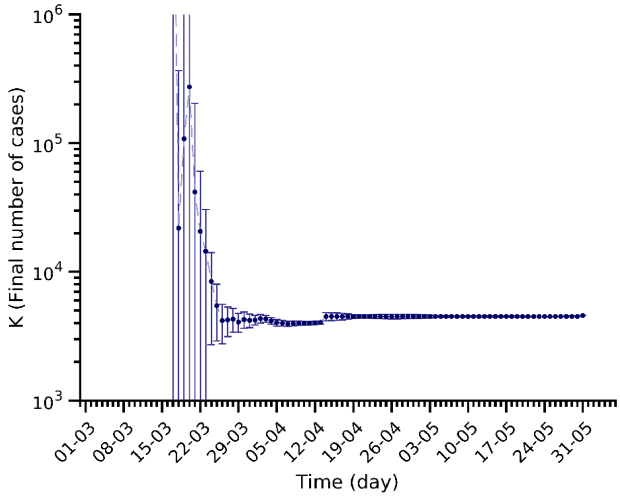


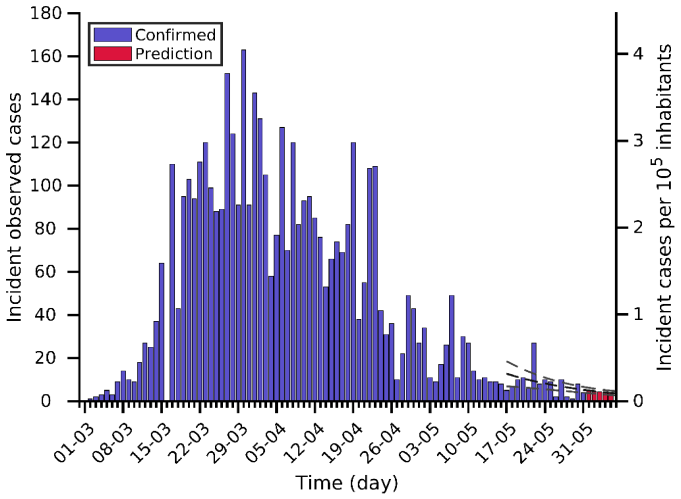
Puglia 31-05-2020. Population: 4.0M. Current cumulated incidence: 112/10^5

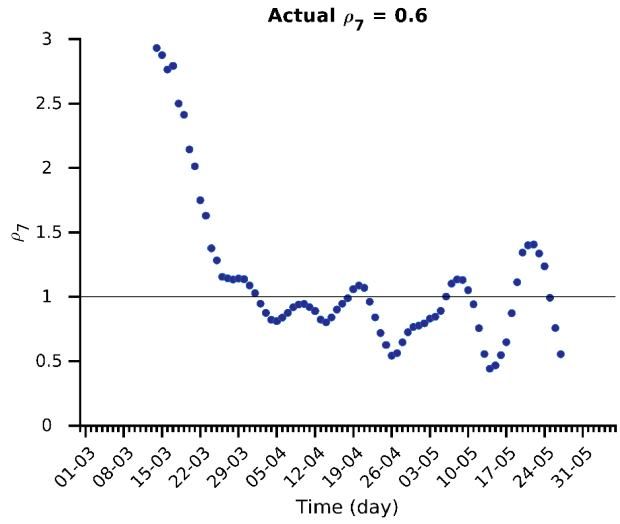


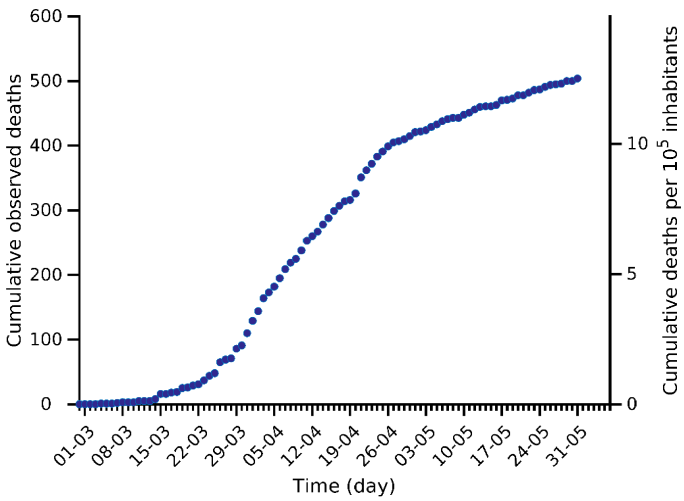


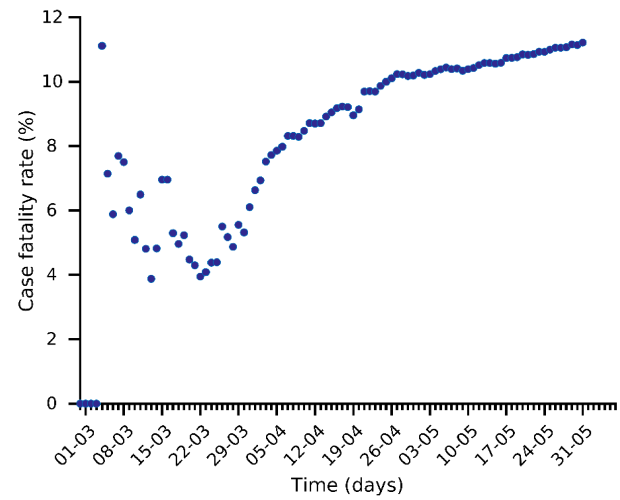




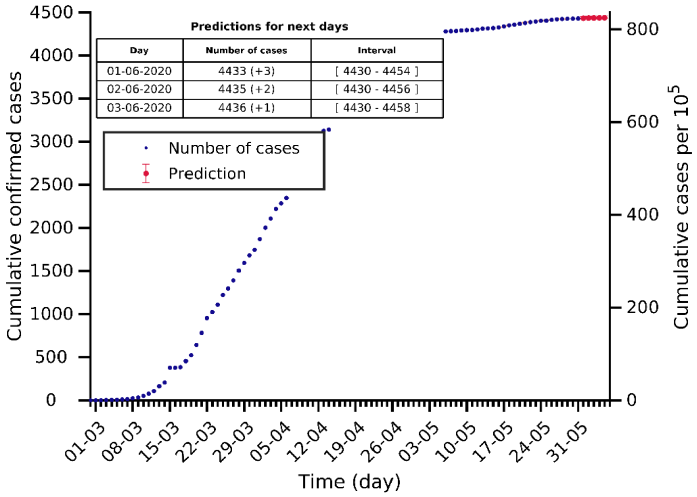


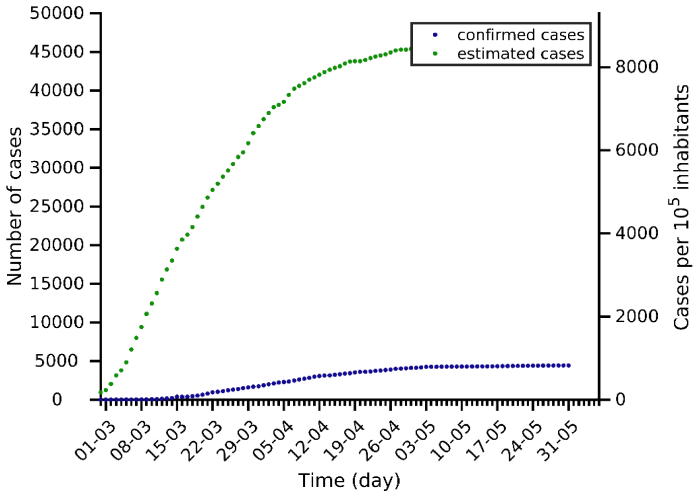


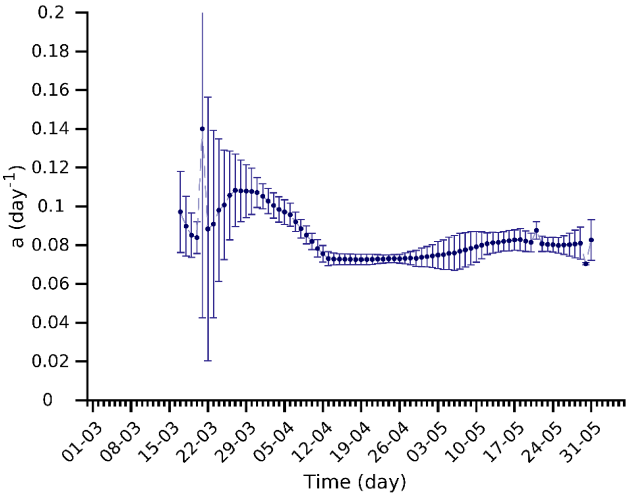


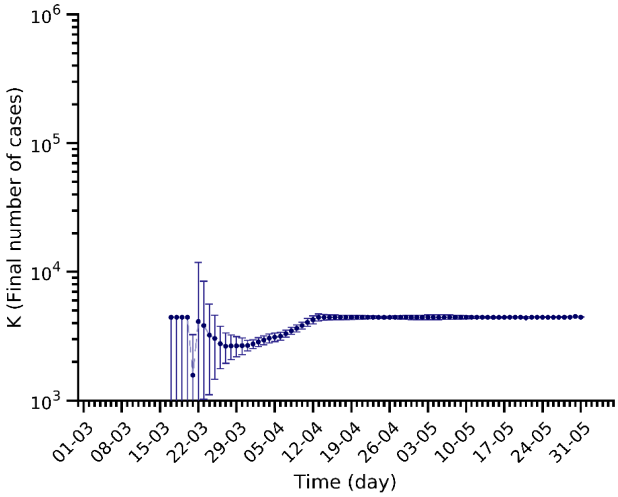


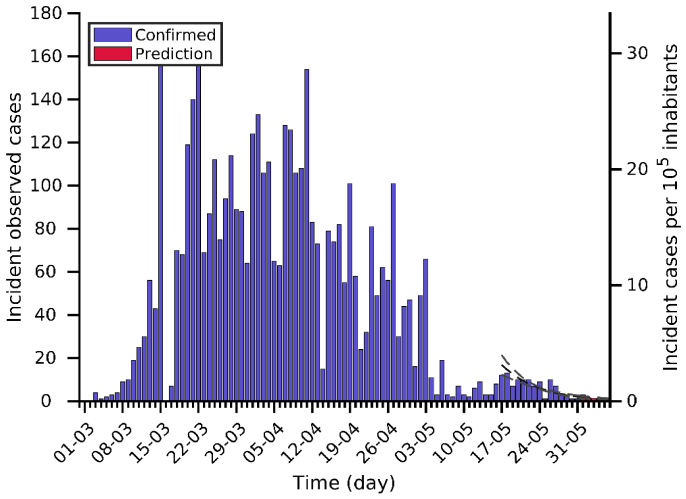
Trento 31-05-2020. Population: 0.5M. Current cumulated incidence: 823/10^5

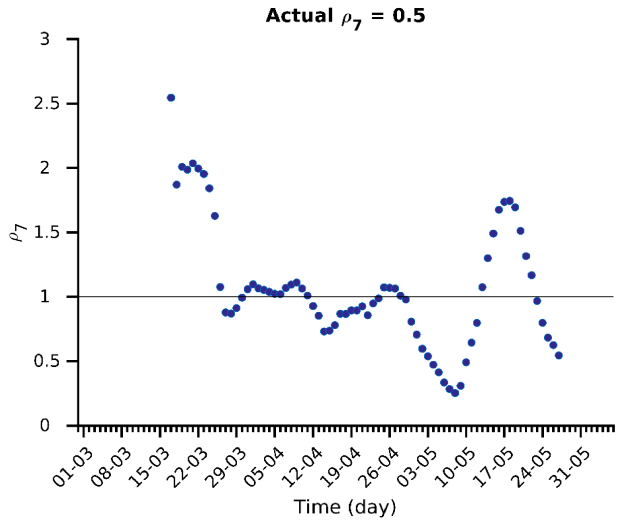


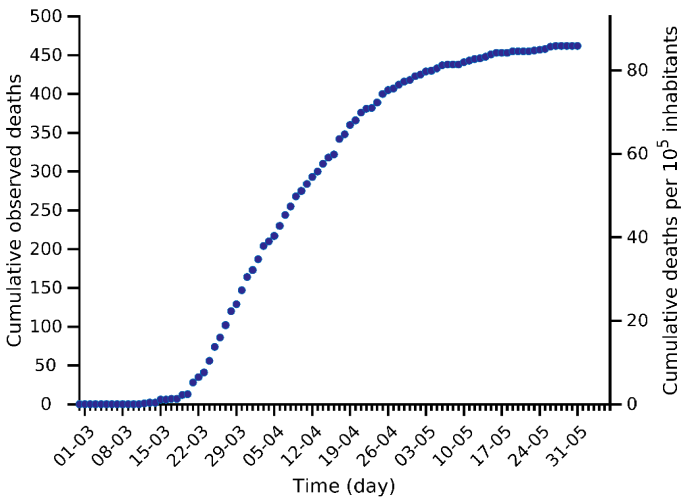


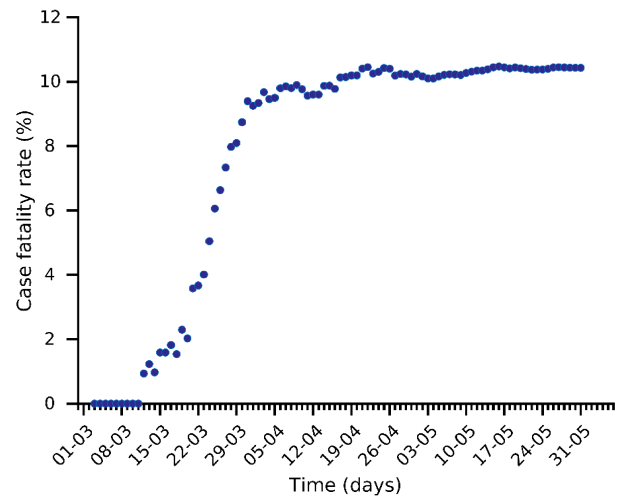




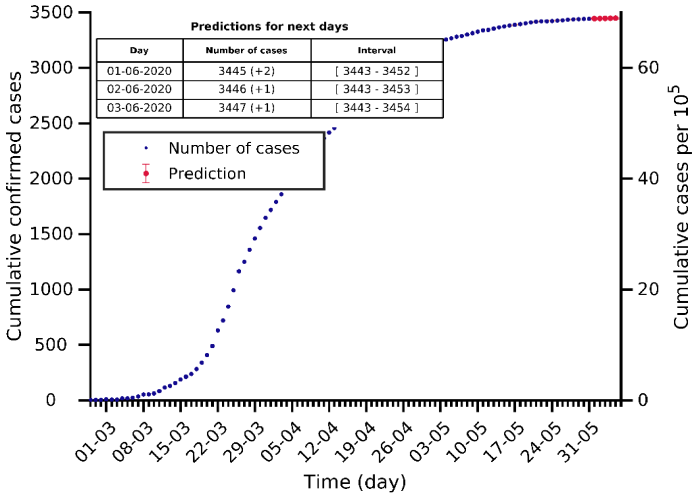


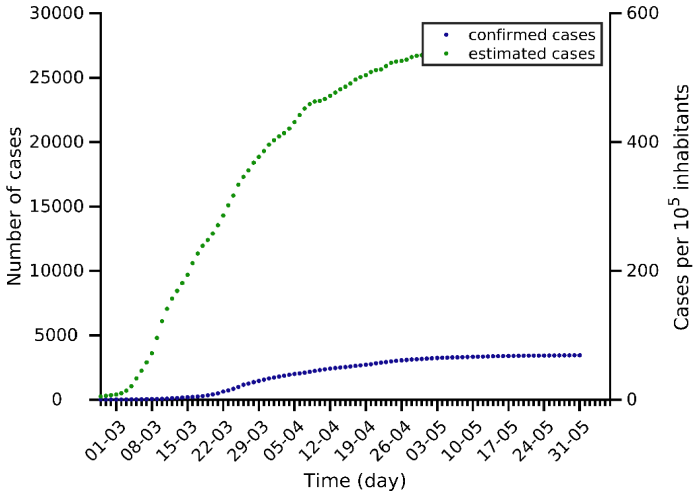


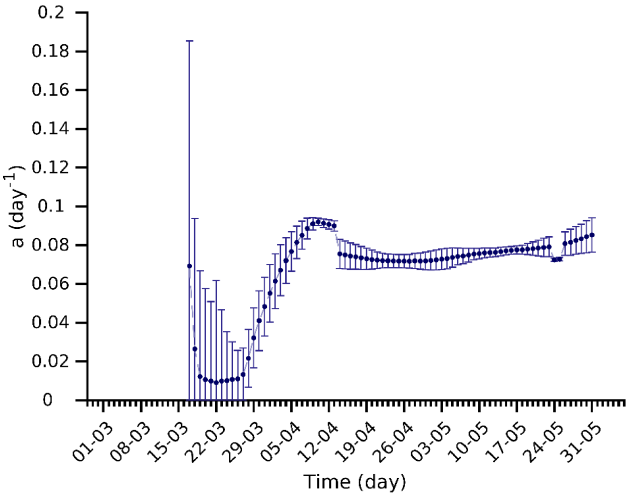


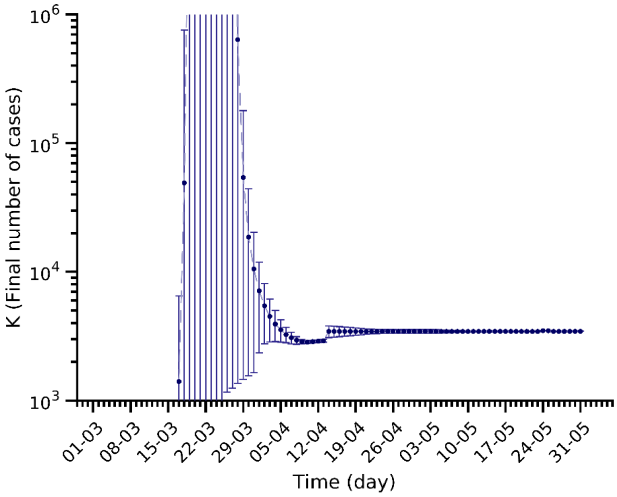


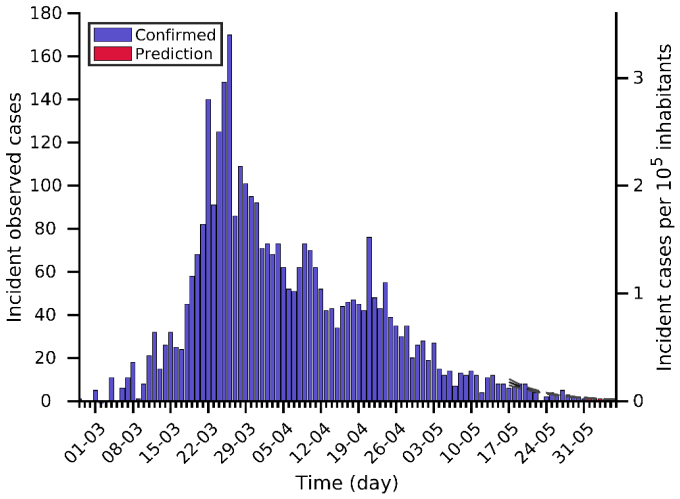
Sicilia 31-05-2020. Population: 5.0M. Current cumulated incidence: 69/10^5

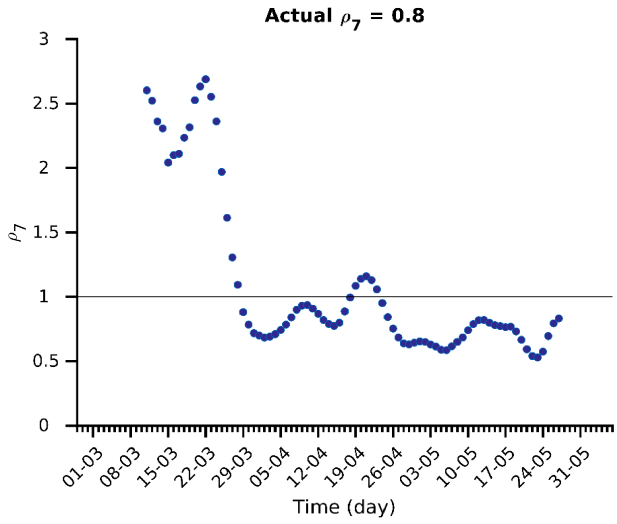


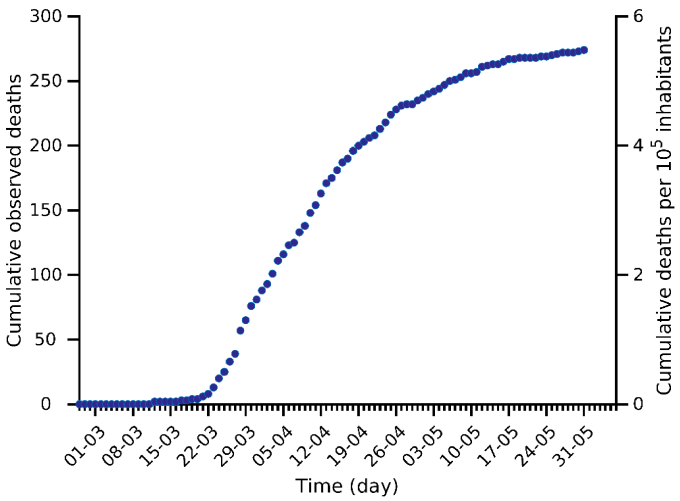


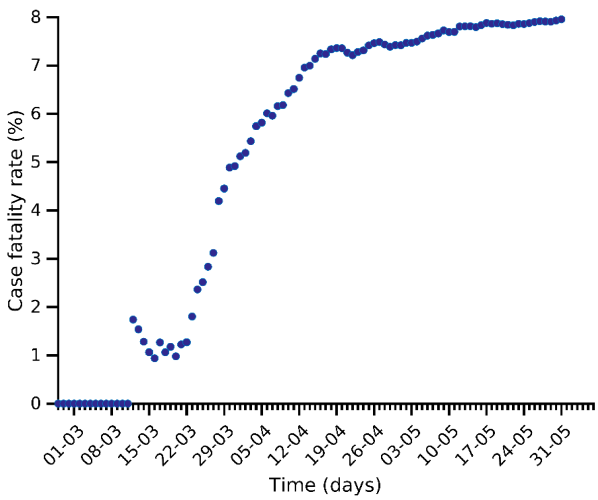




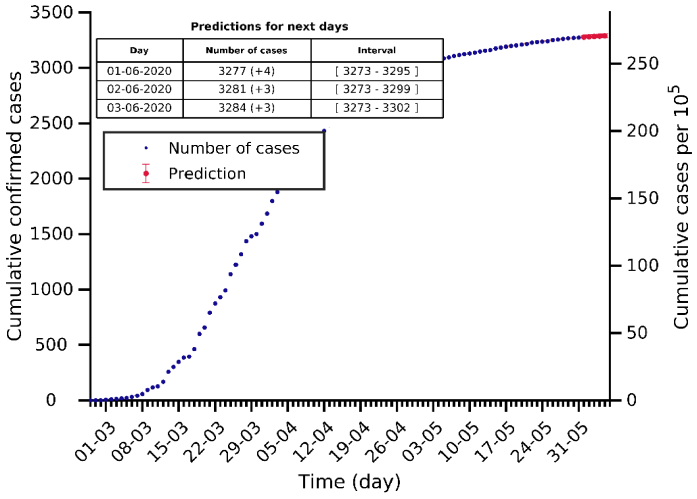


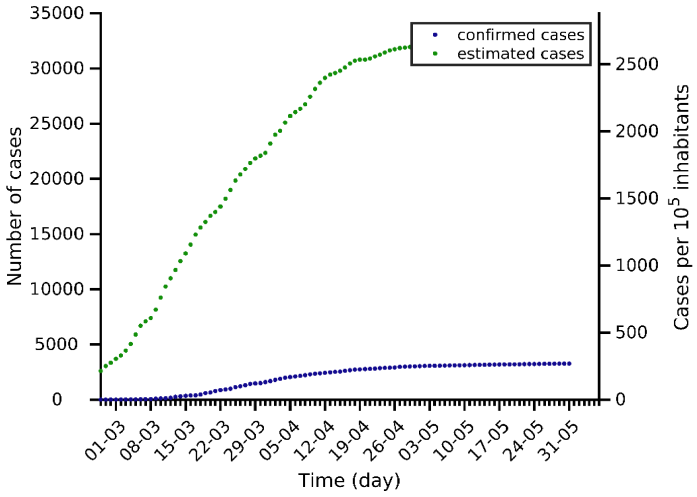


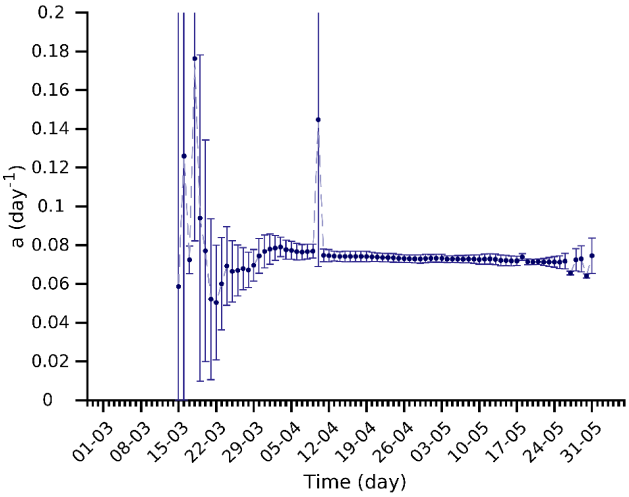


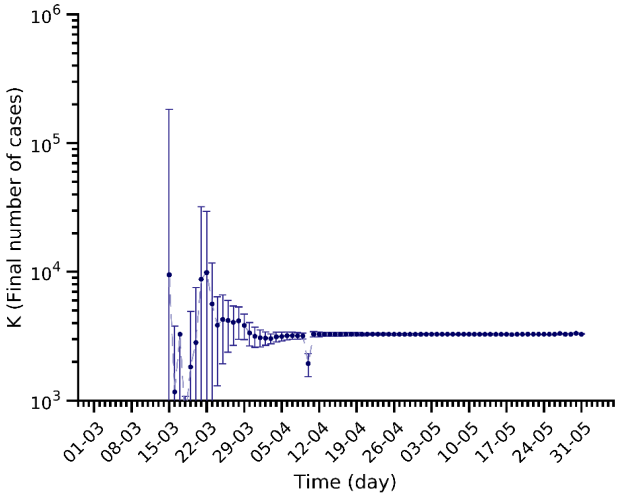


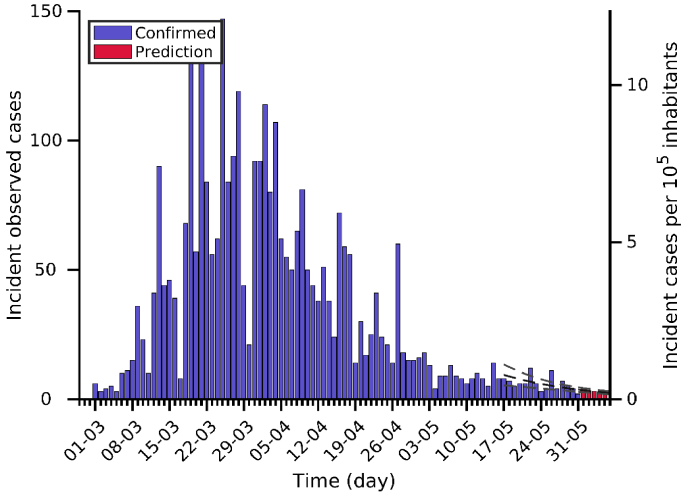
Friuli Venezia Giulia 31-05-2020. Population: 1.2M. Current cumulated incidence: 2

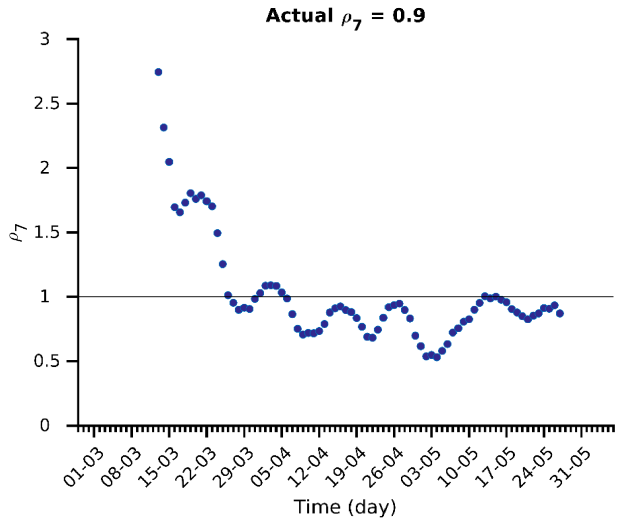


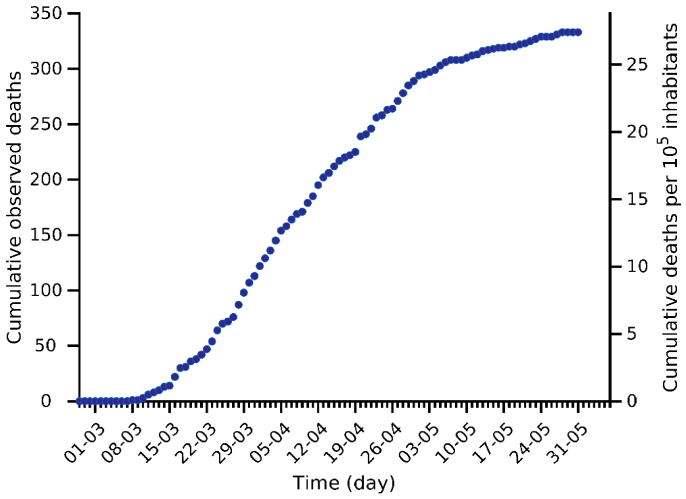


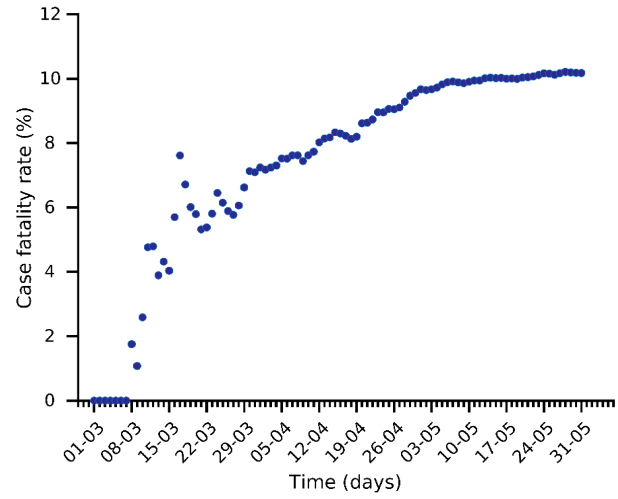




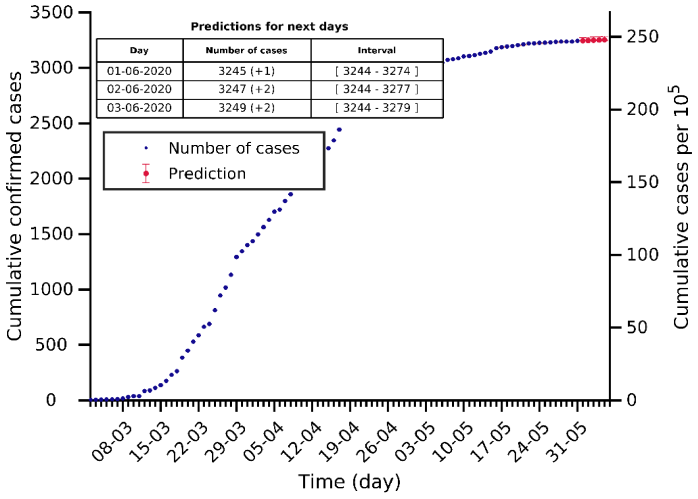


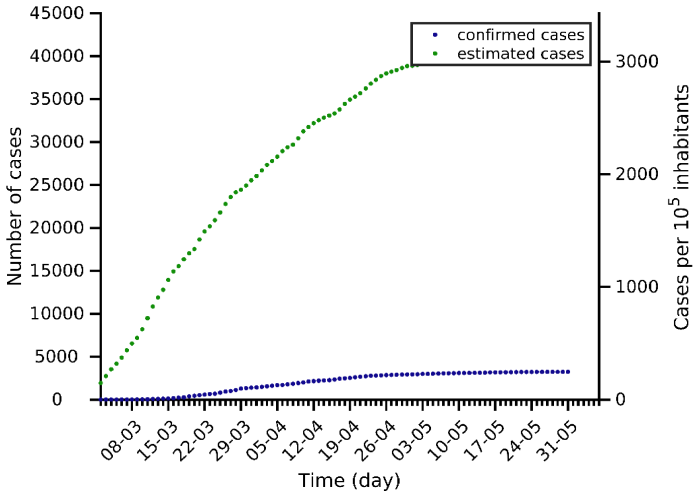


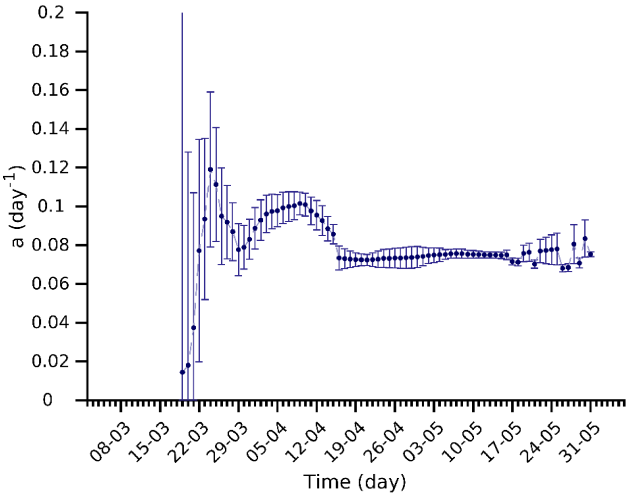


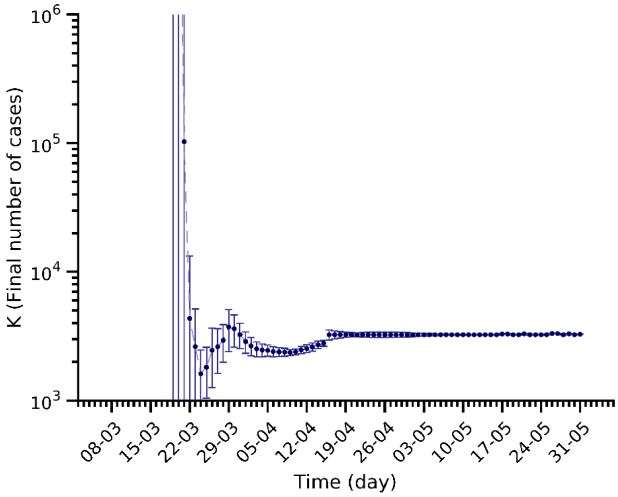


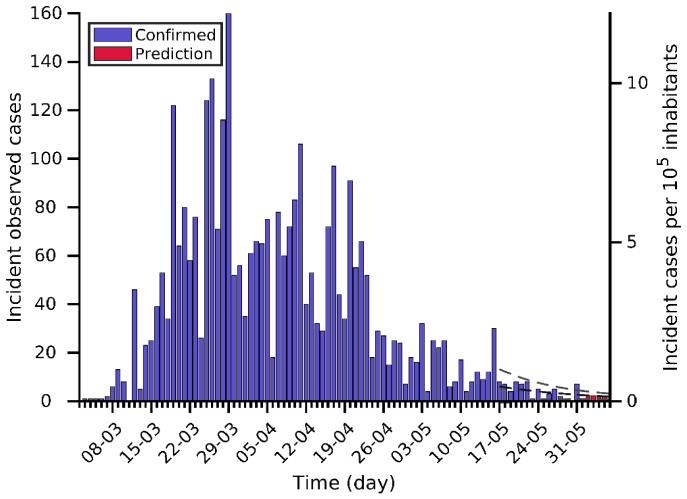
Abruzzo 31-05-2020. Population: 1.3M. Current cumulated incidence: 247/10^5

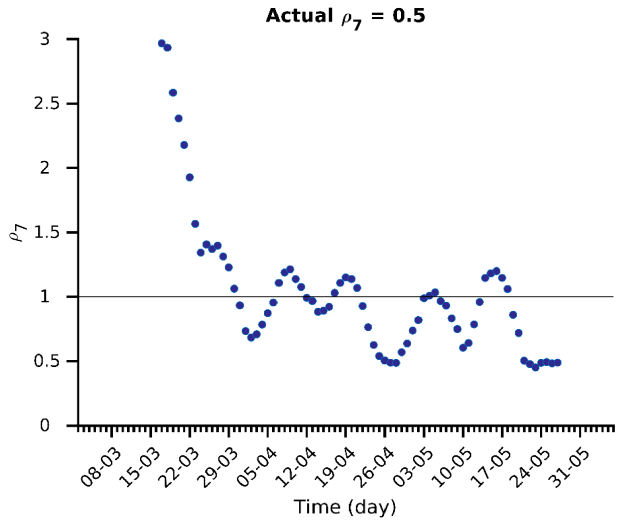


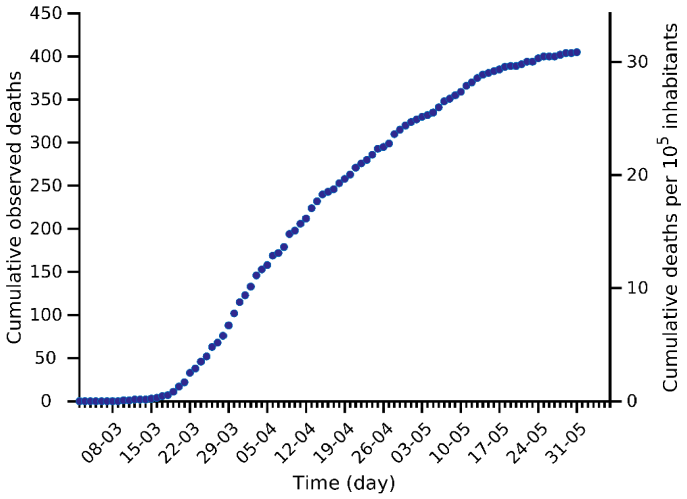


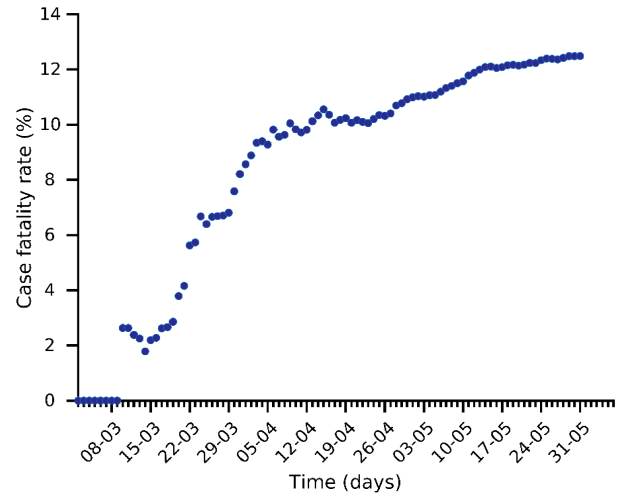




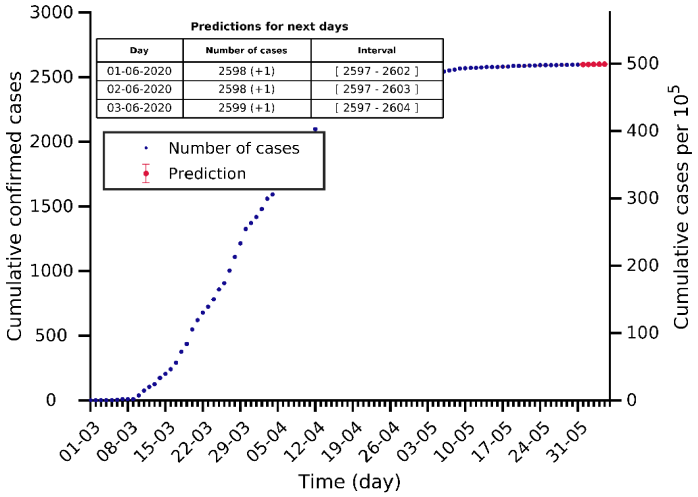


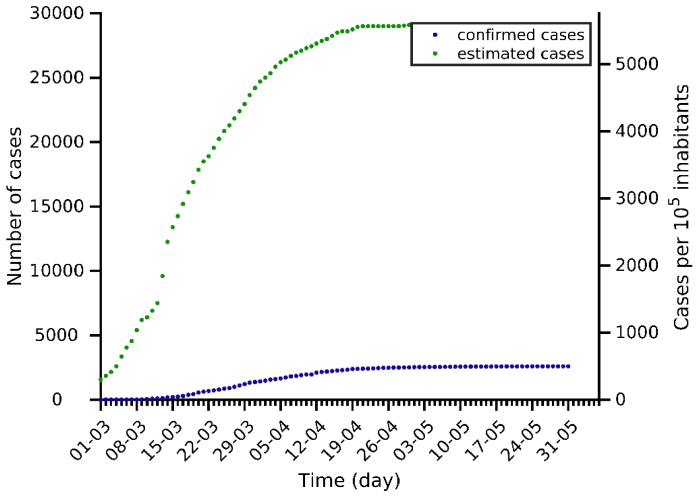


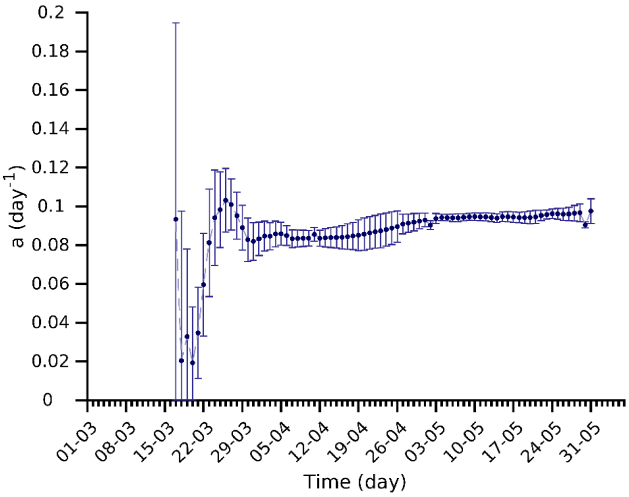


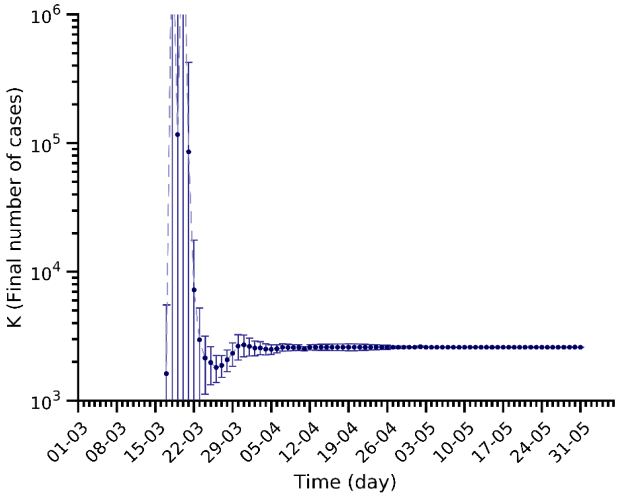


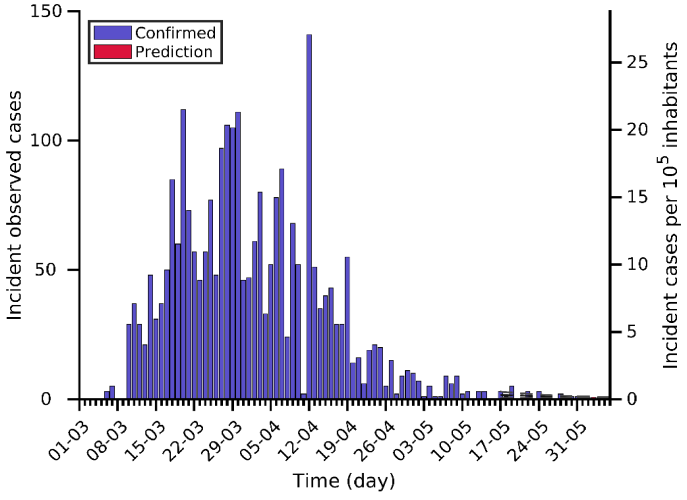
Bolzano 31-05-2020. Population: 0.5M. Current cumulated incidence: 498/10^5

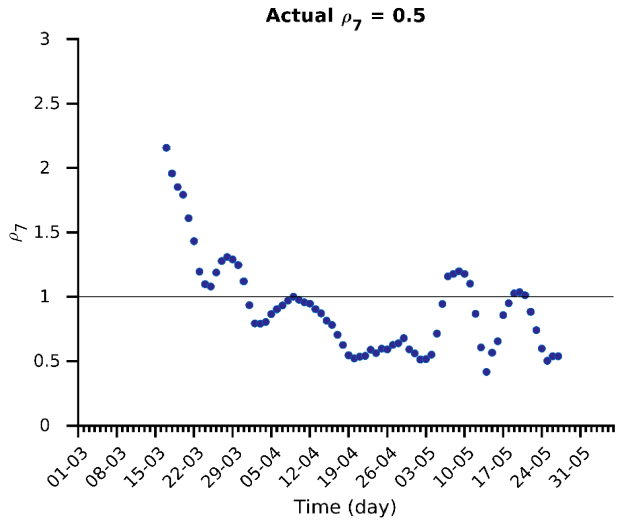


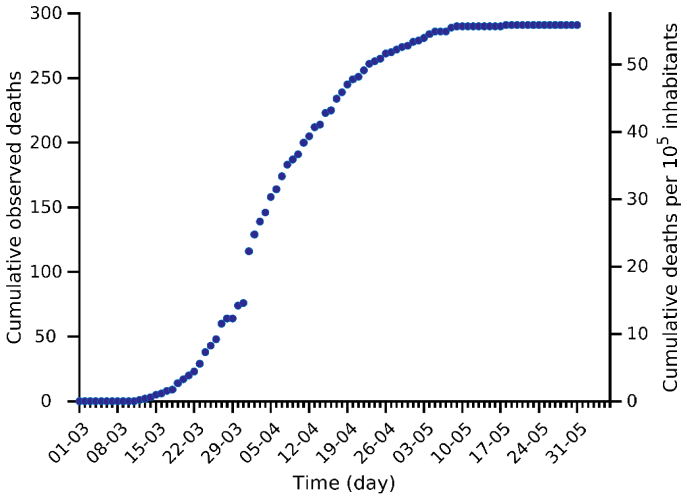


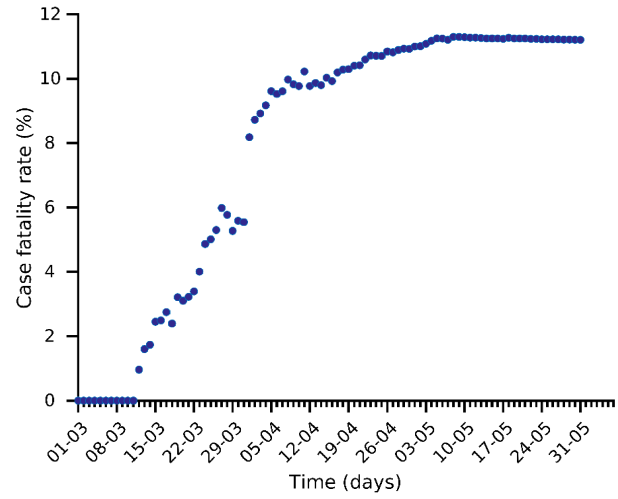




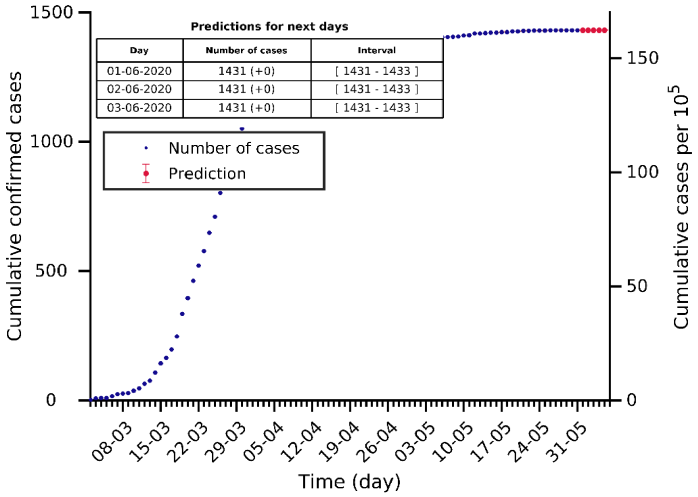


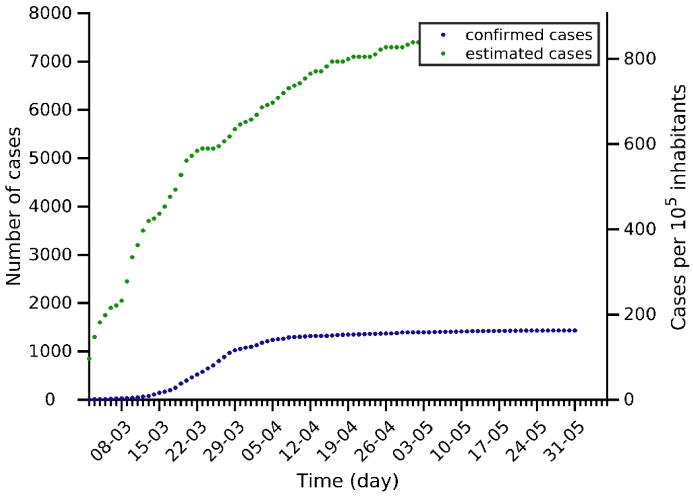


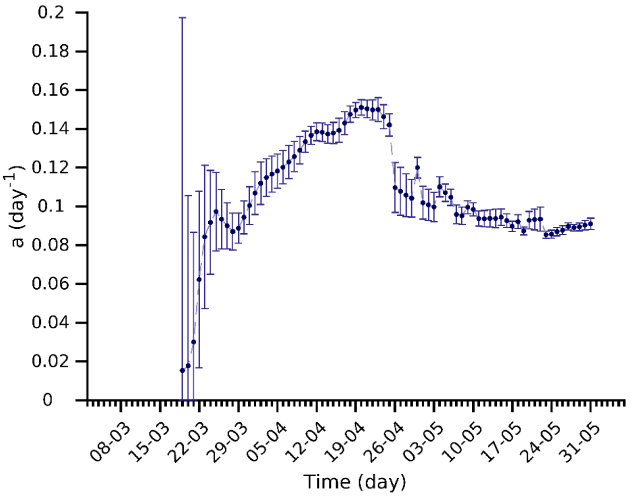


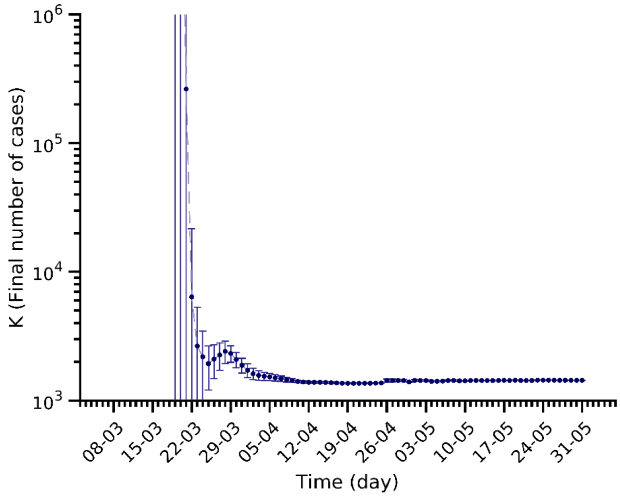


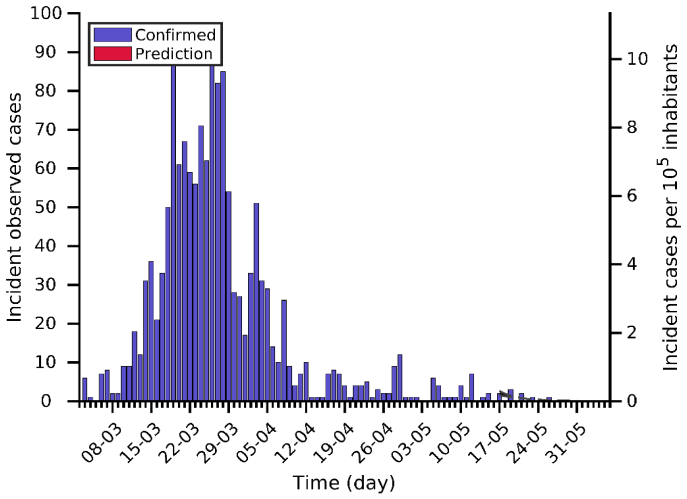
Umbria 31-05-2020. Population: 0.9M. Current cumulated incidence: $162/10^5$

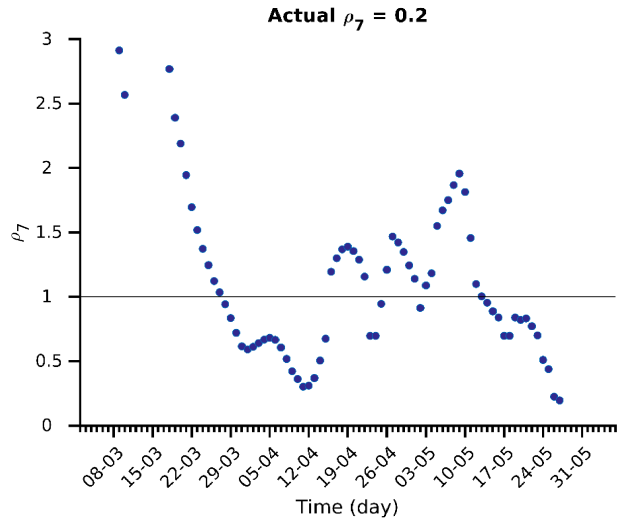


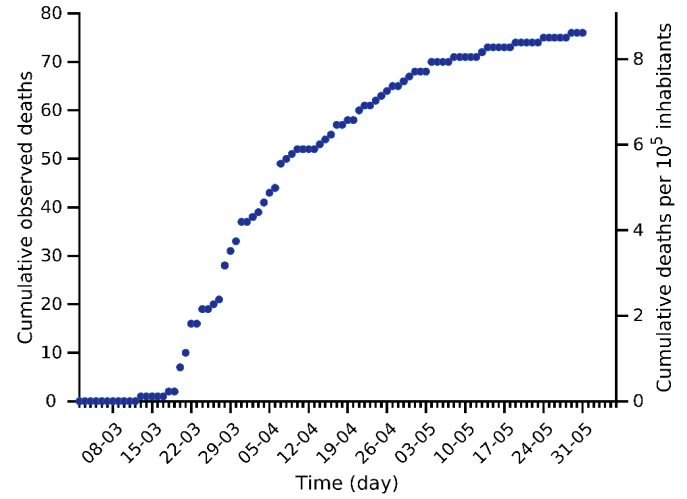


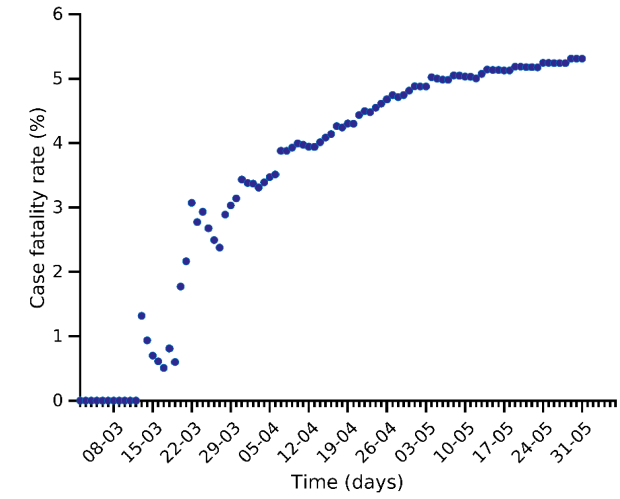








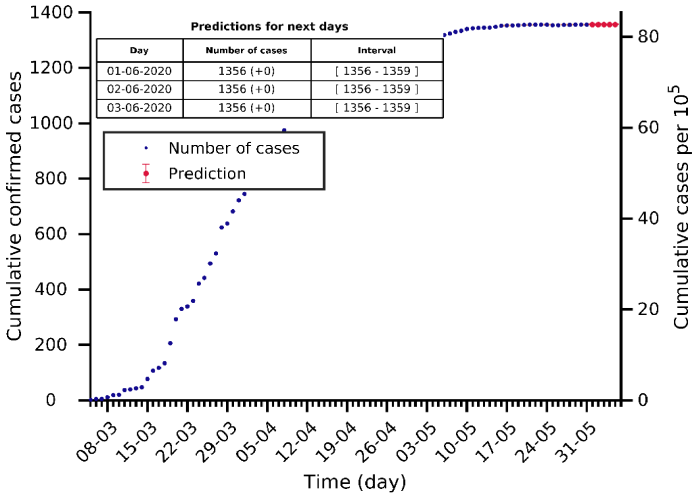


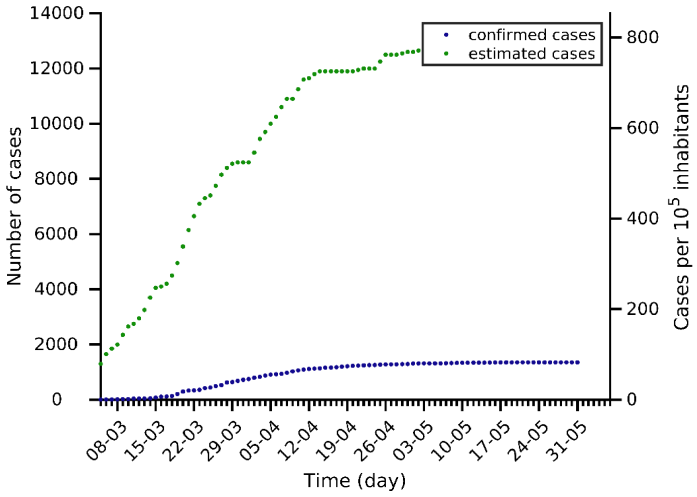


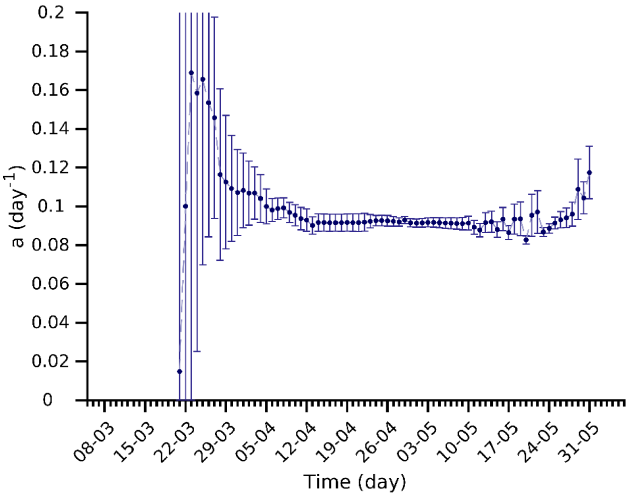
Sardegna 31-05-2020. Population: 1.6M. Current cumulated incidence: 83/10^5

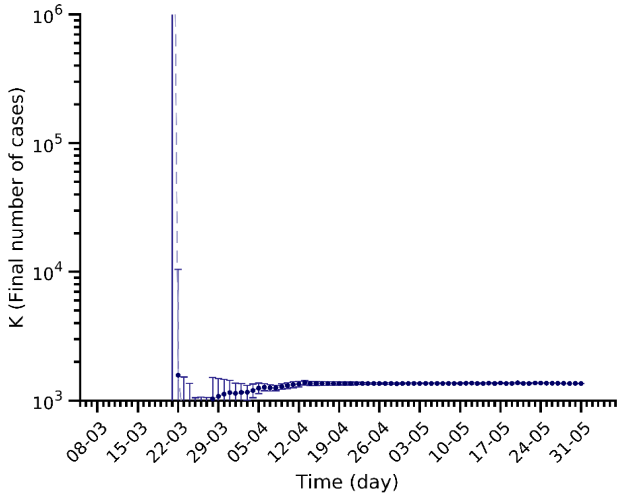
Predictions for next days

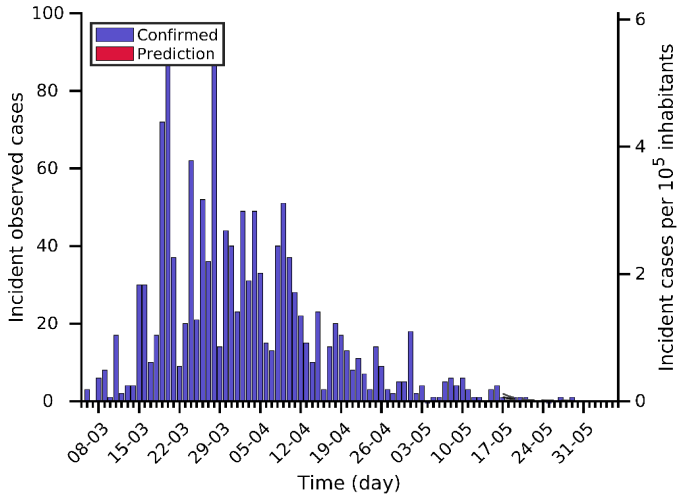
Day	Number of cases	Interval
01-06-2020	1356 (+0)	[1356 - 1359]
02-06-2020	1356 (+0)	[1356 - 1359]
03-06-2020	1356 (+0)	[1356 - 1359]

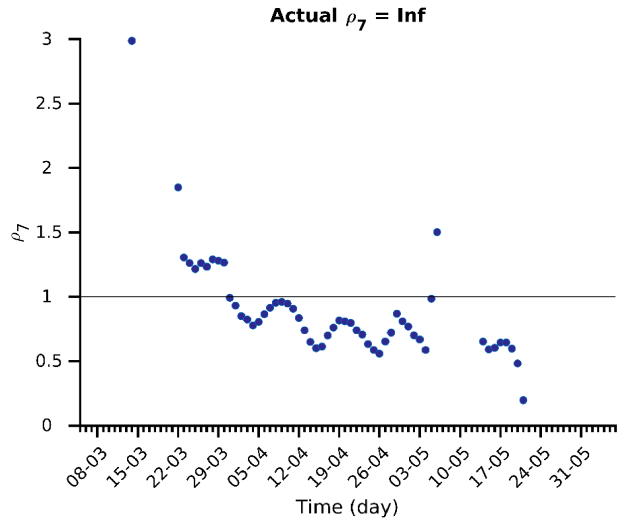


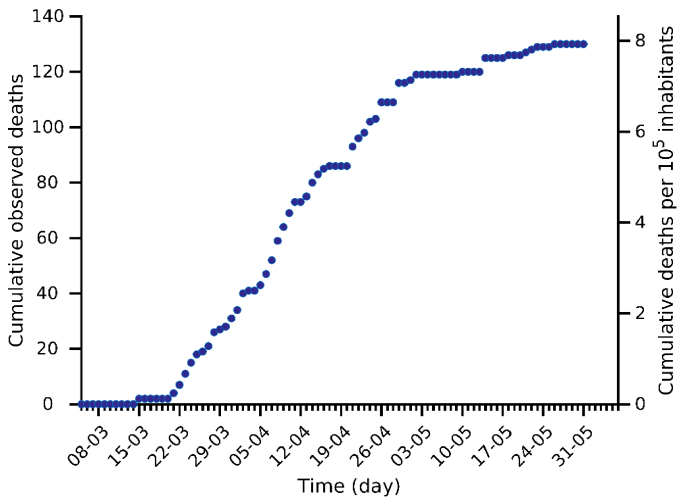


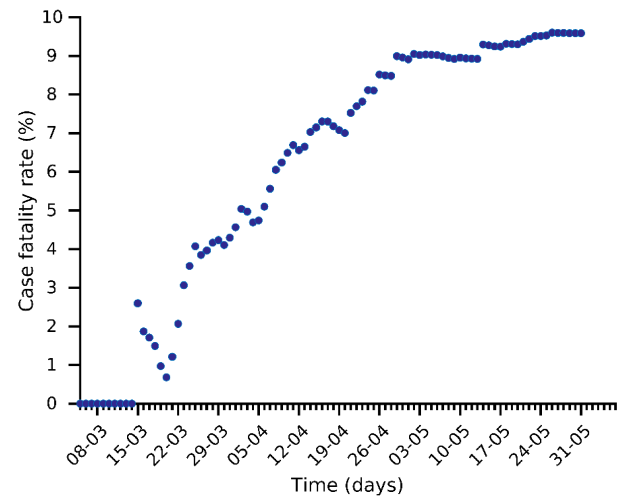




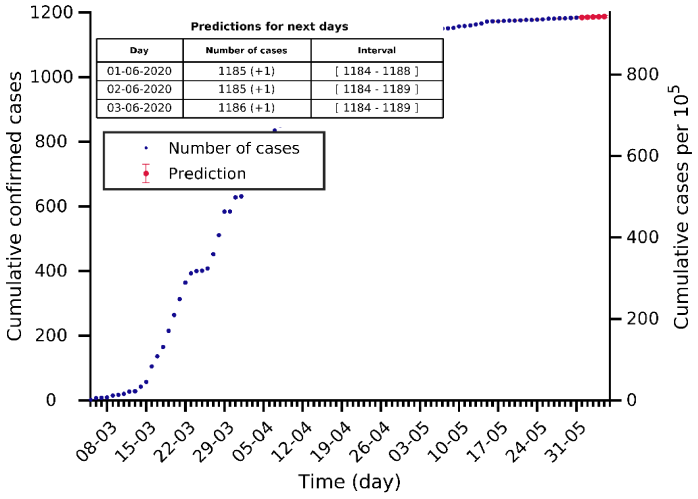


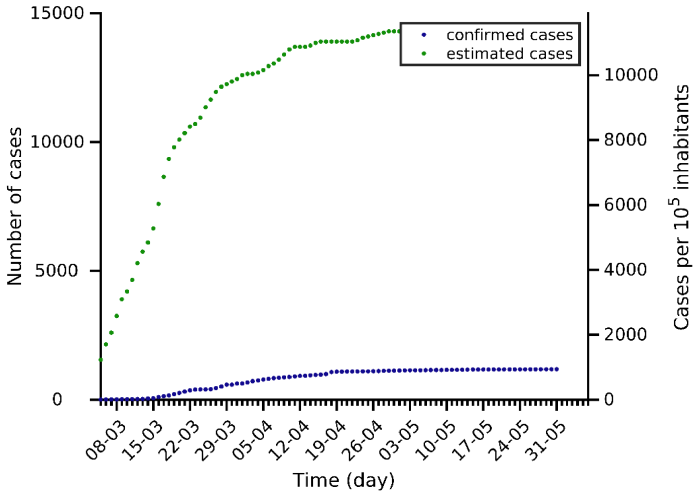


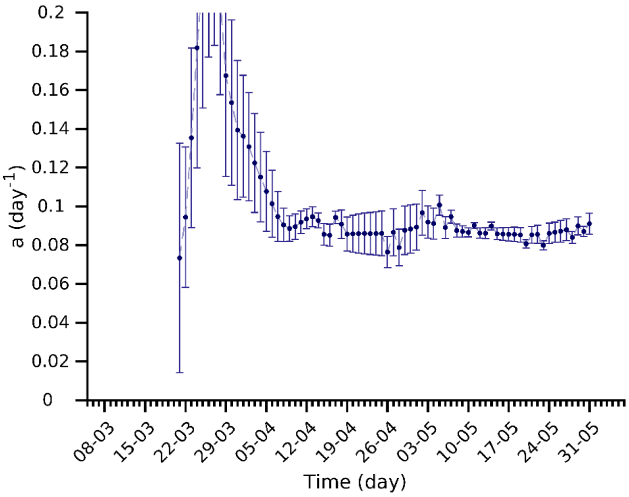


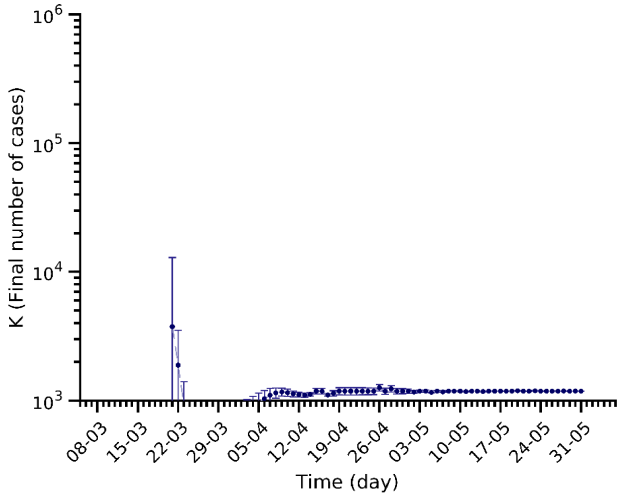


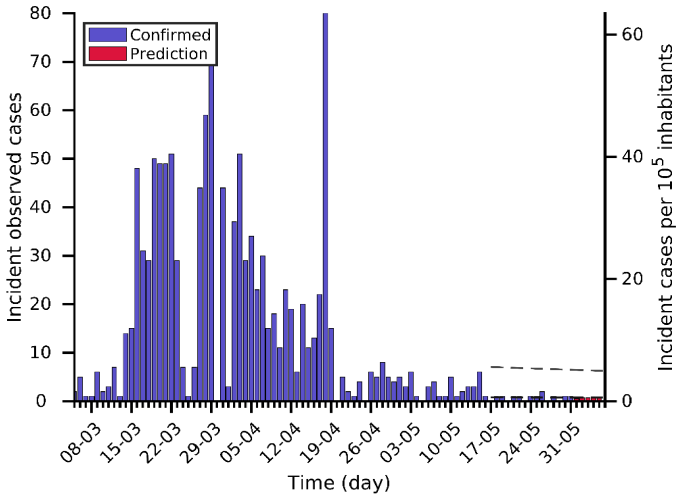
Valle dAosta 31-05-2020. Population: 0.1M. Current cumulated incidence: 940/10^5

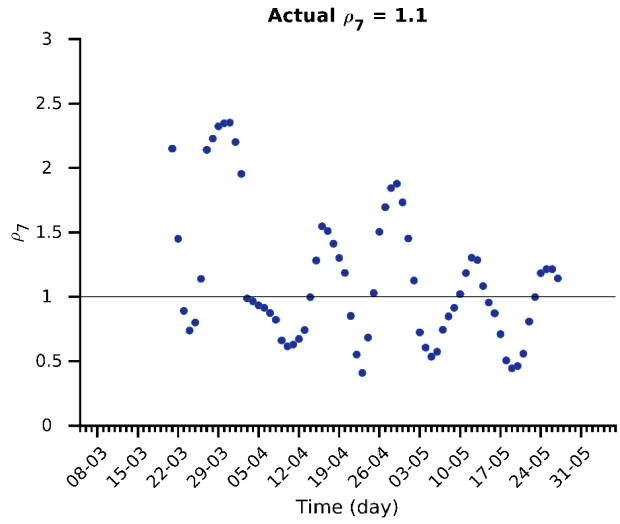


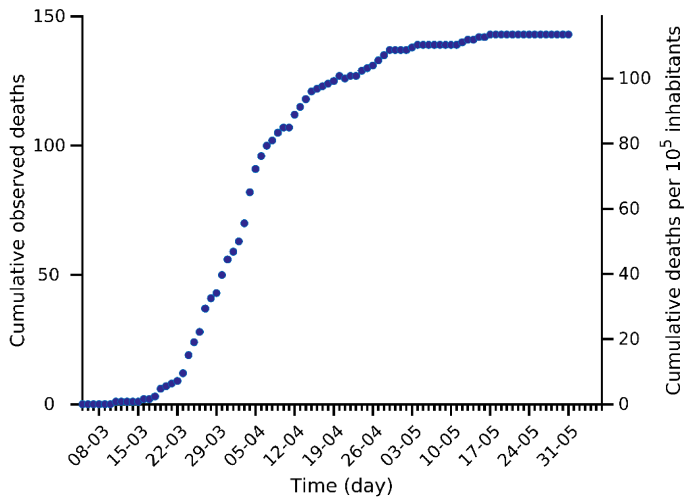


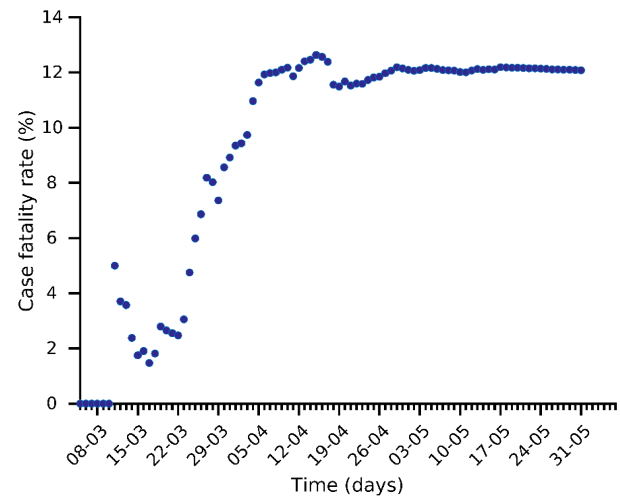




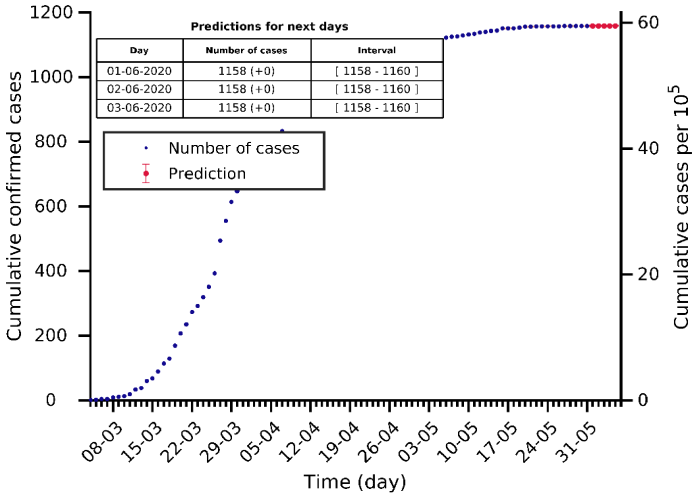


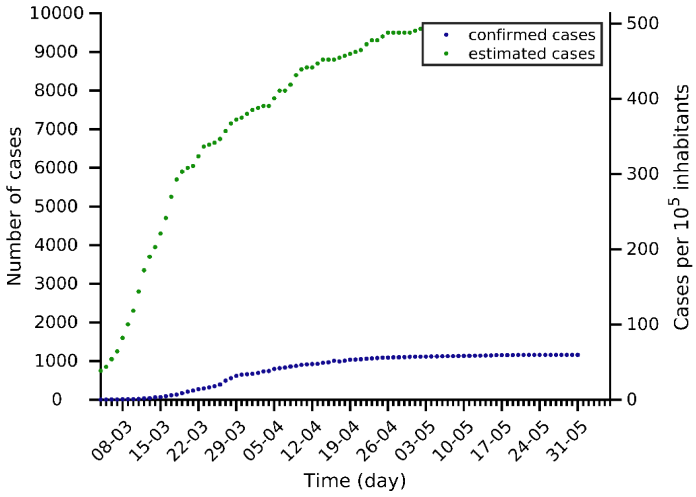


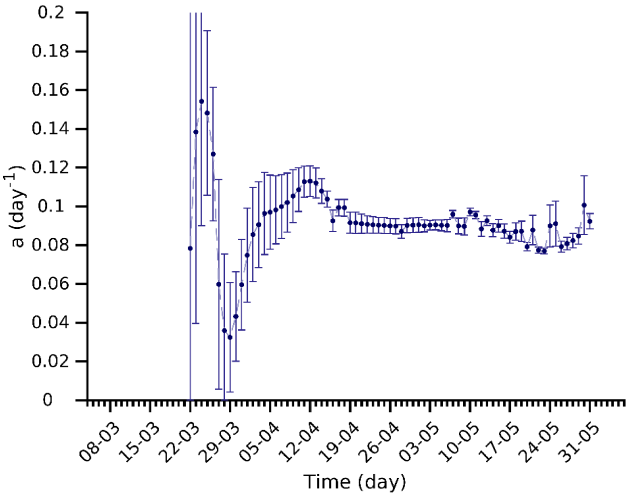


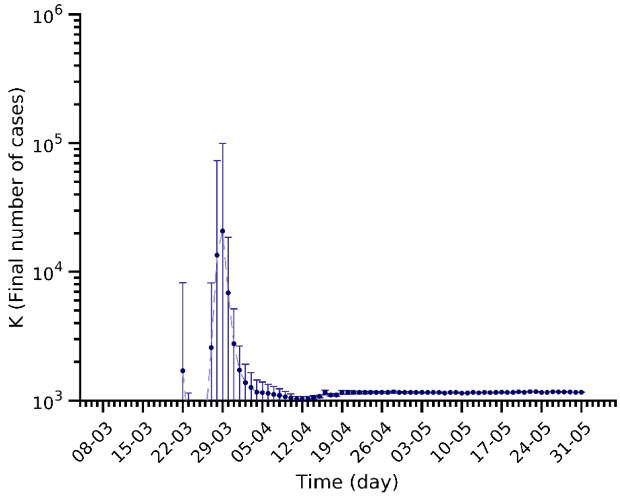


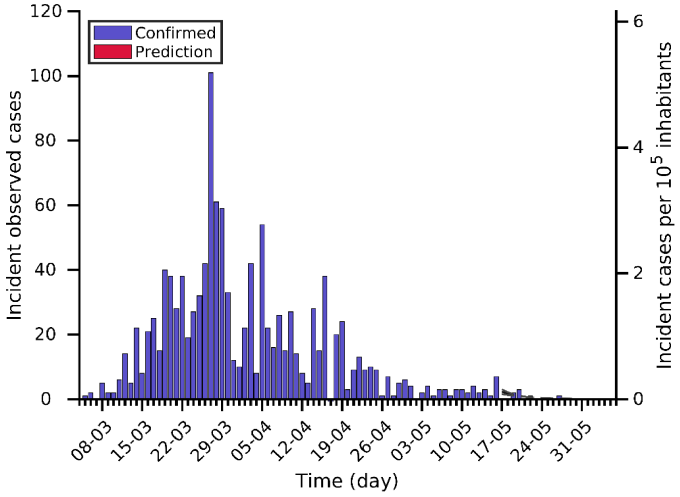
Calabria 31-05-2020. Population: 1.9M. Current cumulated incidence: 59/10^5

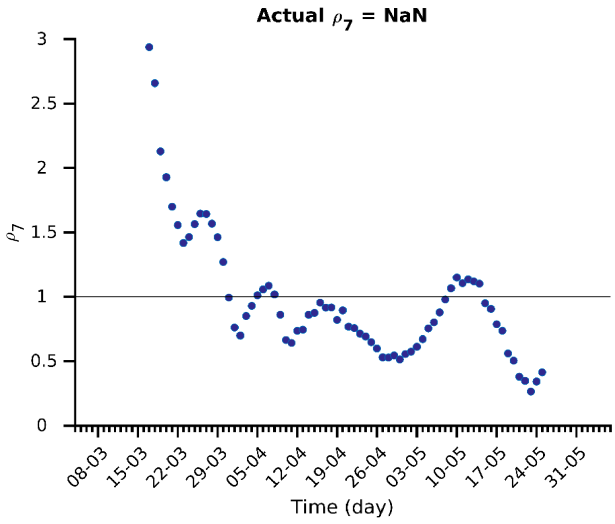


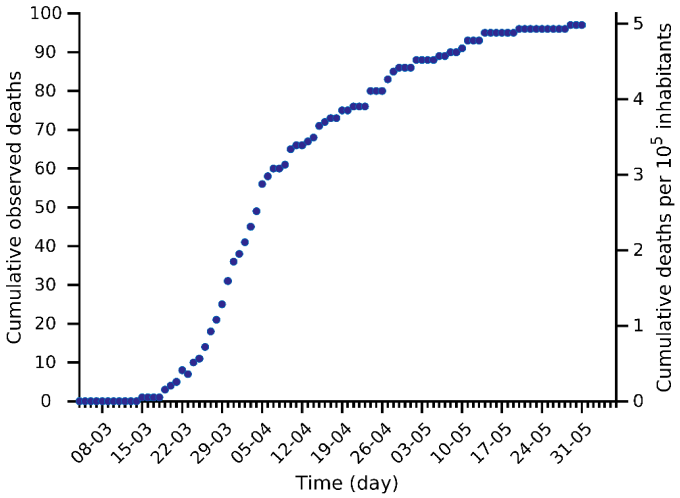


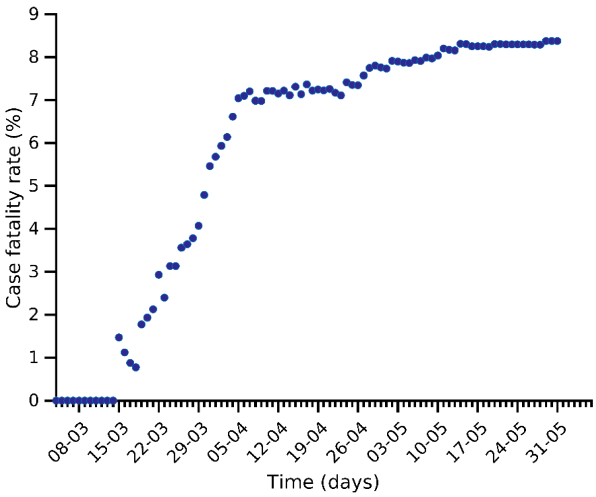




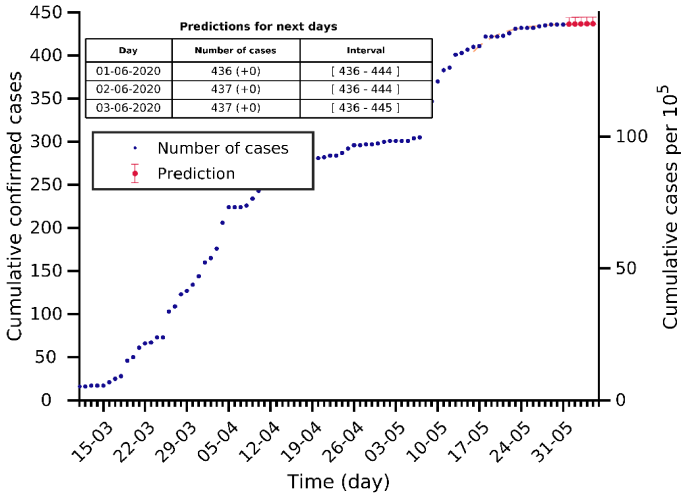


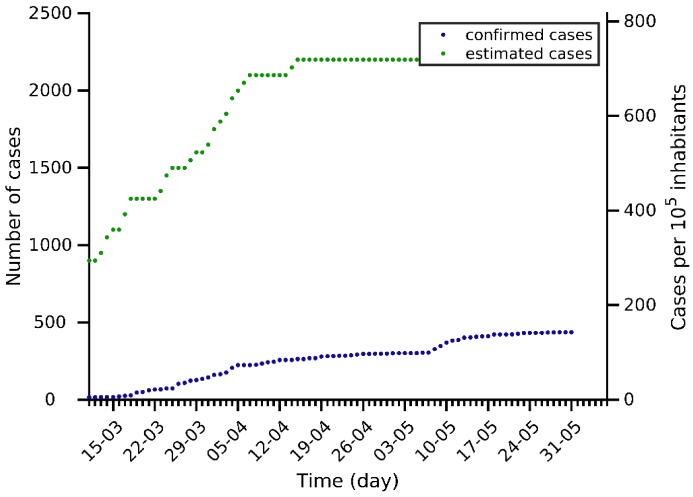


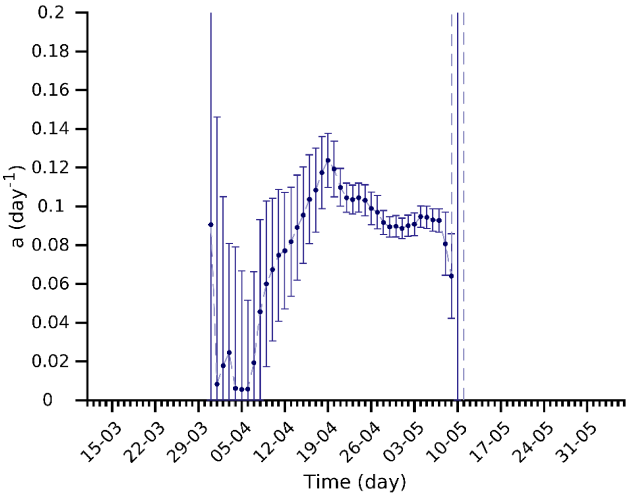


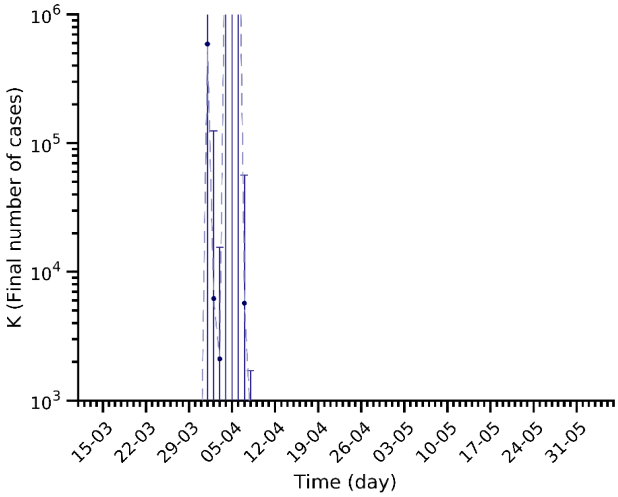


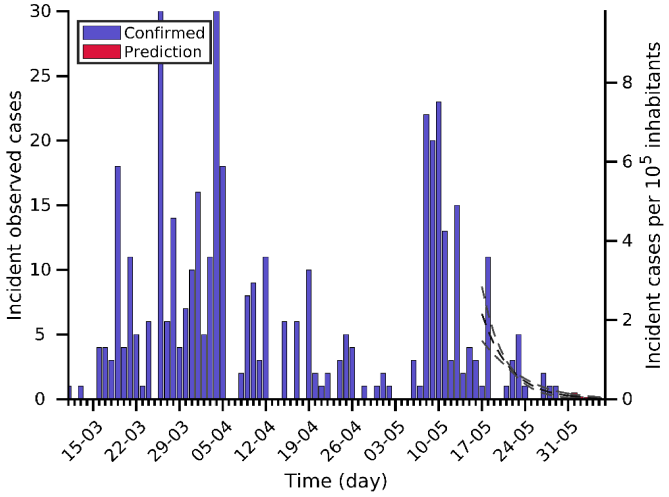
Molise 31-05-2020. Population: 0.3M. Current cumulated incidence: 142/10⁵

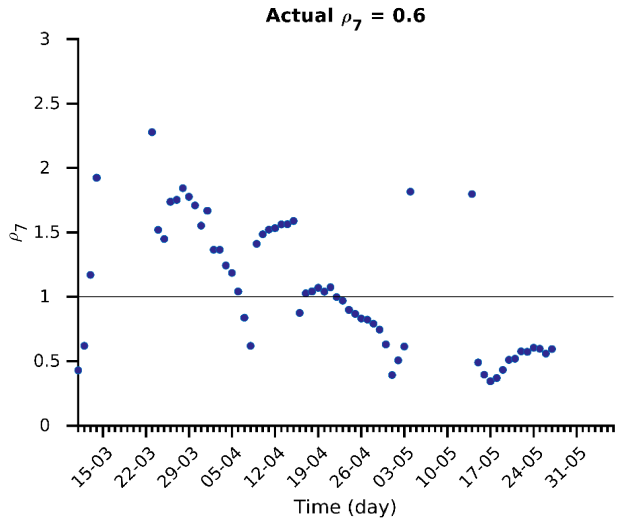


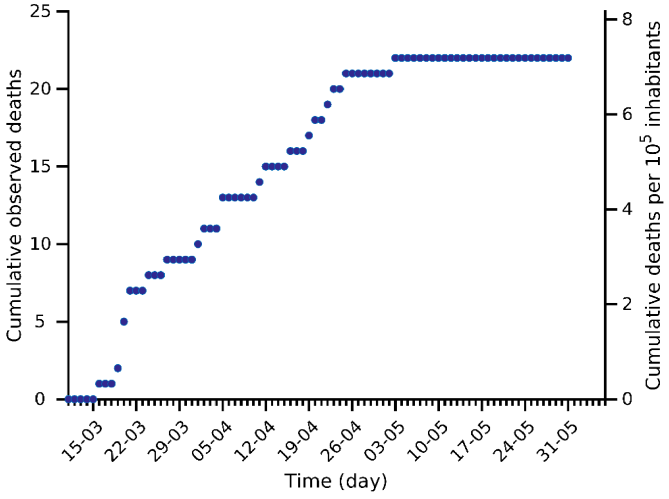


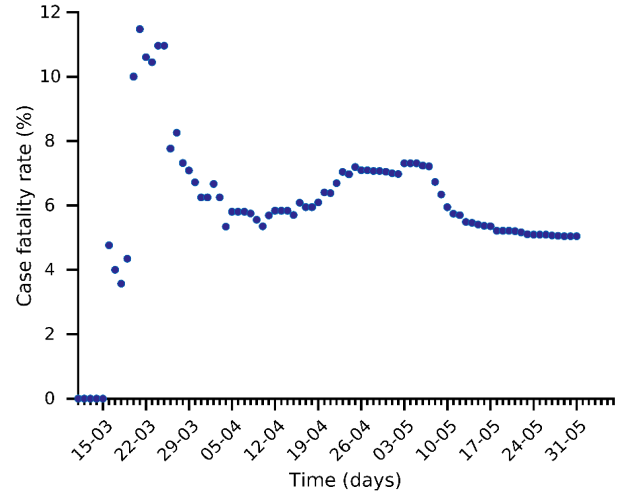




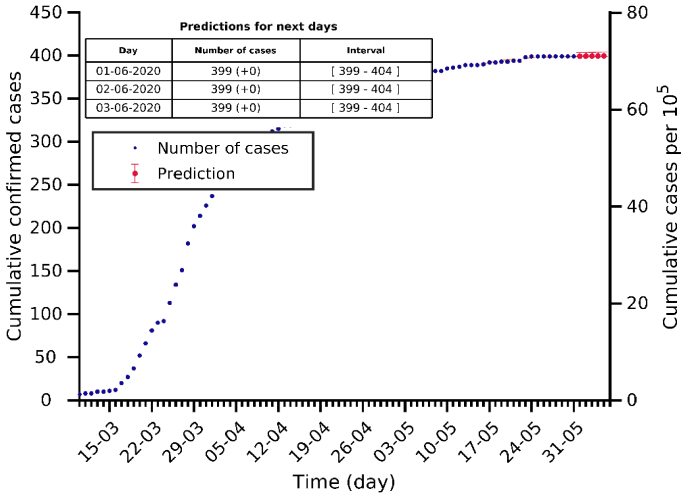


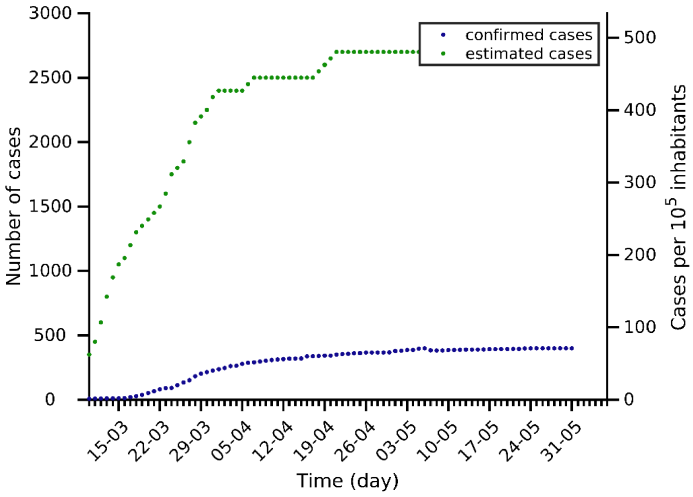


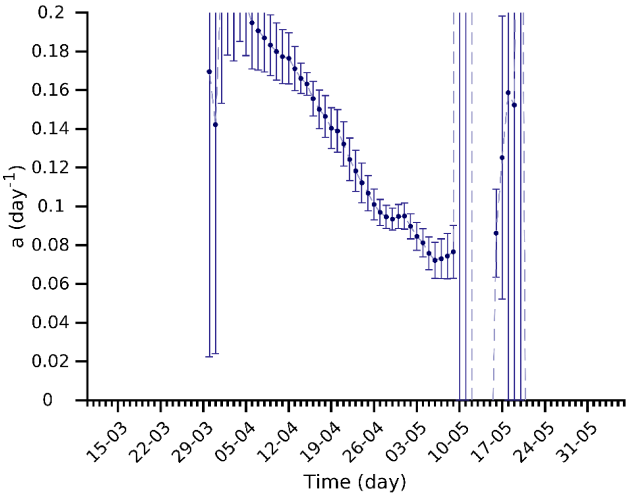


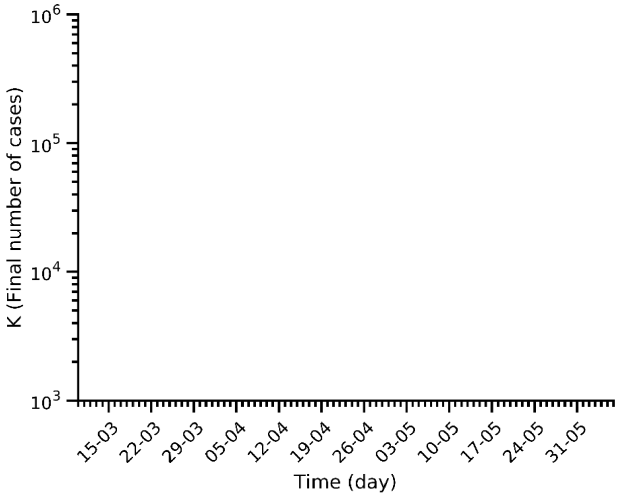


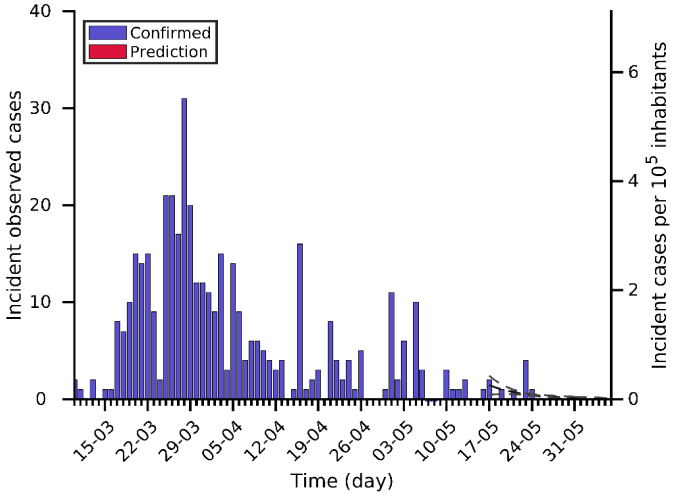
Basilicata 31-05-2020. Population: 0.6M. Current cumulated incidence: 71/10^5

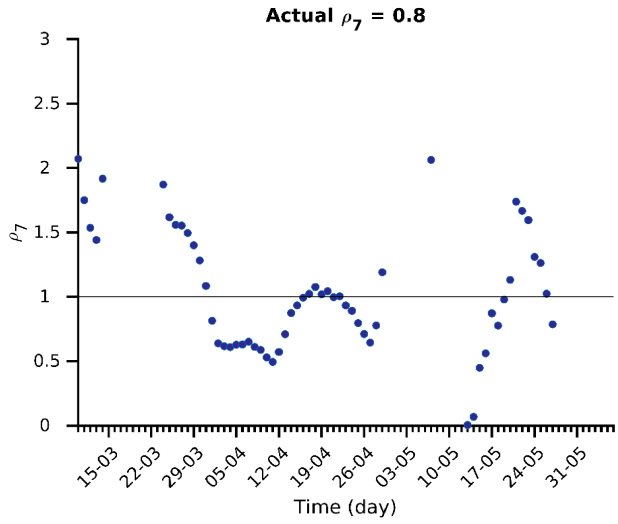


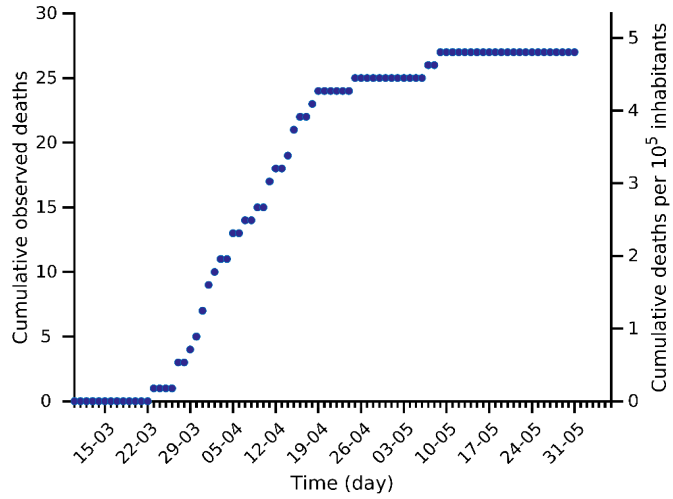


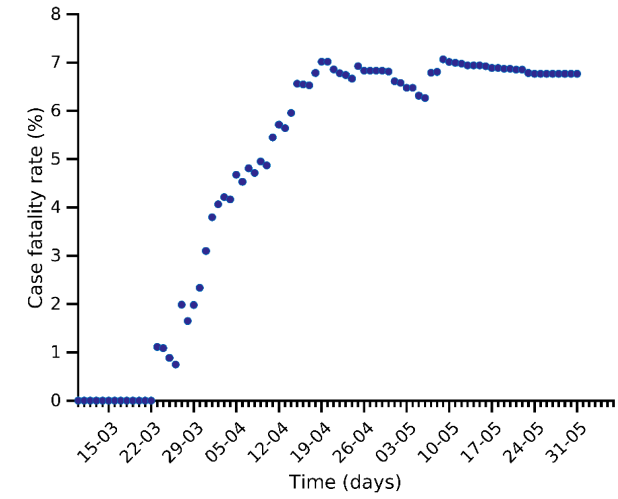












Methods

Methods

(1) Data source

Data are daily obtained from World Health Organization (WHO) surveillance reports[3], from European Centre for Disease Prevention and Control (ECDC)[4] and from Ministerio de Sanidad[5]. These reports are converted into text files that can be processed for subsequent analysis. Daily data comprise, among others: total confirmed cases, total confirmed new cases, total deaths, total new deaths. It must be considered that the report is always providing data from previous day. In the document we use the date at which the datapoint is assumed to belong, i.e., report from 15/03/2020 is giving data from 14/03/2020, the latter being used in the subsequent analysis.

(2) Data processing and plotting

Data are initially processed with Matlab in order to update timeseries, i.e., last datapoints are added to historical sequences. These timeseries are plotted for EU individual countries and for the UE as a whole:

- ✓ Number of cumulated confirmed cases, in blue dots
- ✓ Number of reported new cases
- ✓ Number of cumulated deaths

Then, two indicators are calculated and plotted, too:

- ✓ Number of cumulated deaths divided by the number of cumulated confirmed cases, and reported as a percentage; it is an indirect indicator of the diagnostic level.
- ✓ ρ: this variable is related with the reproduction number, i.e., with the number of new infections caused by a single case. It is evaluated as follows for the day before last report (*t-1*):

$$\rho(t-1) = \frac{N_{new}(t) + N_{new}(t-1) + N_{new}(t-2)}{N_{new}(t-5) + N_{new}(t-6) + N_{new}(t-7)}$$

where $N_{new}(t)$ is the number of new confirmed cases at day t.

(3) Classification of countries according to their status in the epidemic cycle

The evolution of confirmed cases shows a biphasic behaviour:

(I) an initial period where most of the cases are imported;
(II) a subsequent period where most of new cases occur because of local transmission.

Once in the stage II, mathematical models can be used to track evolutions and predict tendencies. Focusing on countries that are on stage II, we classify them in three groups:

- Group A: countries that have reported more than 100 cumulated cases for 10 consecutive days or more;
- Group B: countries that have reported more than 100 cumulated cases for 7 to 9 consecutive days;
- Group C: countries that have reported more than 100 cumulated cases for 4 to 6 days.

[3] https://www.who.int/emergencies/diseases/novel-coronavirus-2019/situation-reports
[4] https://www.ecdc.europa.eu/en/geographical-distribution-2019-ncov-cases
[5] https://www.mscbs.gob.es/profesionales/saludPublica/ccayes/alertasActual/nCov-China/situacionActual.htm https://github.com/datadista/datasets/tree/master/COVID%2019 , https://covid19.isciii.es/

(4) Fitting a mathematical model to data

Previous studies have shown that Gompertz model[6] correctly describes the Covid-19 epidemic in all analysed countries. It is an empirical model that starts with an exponential growth but that gradually decreases its specific growth rate. Therefore, it is adequate for describing an epidemic that is characterized by an initial exponential growth but a progressive decrease in spreading velocity provided that appropriate control measures are applied.

Gompertz model is described by the equation:

$$N(t) = K\, e^{-ln\left(\frac{K}{N_0}\right)\cdot e^{-a\cdot(t-t_0)}}$$

where *N(t)* is the cumulated number of confirmed cases at *t* (in days), and N_0 is the number of cumulated cases the day at day t_0. The model has two parameters:

- ✓ *a* is the velocity at which specific spreading rate is slowing down;
- ✓ *K* is the expected final number of cumulated cases at the end of the epidemic.

This model is fitted to reported cumulated cases of the UE and of countries in stage II that accomplish two criteria: 4 or more consecutive days with more than 100 cumulated cases, and at least one datapoint over 200 cases. Day t_0 is chosen as that one at which *N(t)* overpasses 100 cases. If more than 15 datapoints that accomplish the stated criteria are available, only the last 15 points are used. The fitting is done using Matlab's Curve Fitting package with Nonlinear Least Squares method, which also provides confidence intervals of fitted parameters (*a* and *K*) and the R^2 of the fitting. At the initial stages the dynamics is exponential and *K* cannot be correctly evaluated. In fact, at this stage the most relevant parameter is *a*. Fitted curves are incorporated to plots of cumulative reported cases with a dashed line. Once a new fitting is done, two plots are added to the country report:

- ✓ Evolution of fitted *a* with its error bars, i.e., values obtained on the fitting each day that the analysis has been carried out;
- ✓ Evolution of fitted *K* with its error bars, i.e., values obtained on the fitting each day that the analysis has been carried out; if lower error bar indicates a value that is lower than current number of cases, the error bar is truncated.

These plots illustrate the increase in fittings' confidence, as fitted values progressively stabilize around a certain value and error bars get smaller when the number of datapoints increases. In fact, in the case of countries, they are discarded and set as "Not enough data" if $a>0.2\ day^{-1}$, if $K>10^6$ or if the error in K overpasses 10^6.

It is worth to mention that the simplicity of this model and the lack of previous assumptions about the Covid-19 behaviour make it appropriate for universal use, i.e., it can be fitted to any country independently of its socioeconomic context and control strategy. Then, the model is capable of quantifying the observed dynamics in an objective and standard manner and predicting short-term tendencies.

(5) Using the model for predicting short-term tendencies

The model is finally used for a short-term prediction of the evolution of the cumulated number of cases. The predictions increase their reliability with the number of datapoints used in the fitting. Therefore, we consider three levels of prediction, depending on the country:

[6] Madden LV. Quantification of disease progression. Protection Ecology 1980; **2**: 159-176.

- Group A: prediction of expected cumulated cases for the following 3-5 days[7];
- Group B: prediction of expected cumulated cases for the following 2 days;
- Group C: prediction of expected cumulated cases for the following day.

The confidence interval of predictions is assessed with the Matlab function `predint`, with a 99% confidence level. These predictions are shown in the plots as red dots with corresponding error bars, and also gathered in the attached table. For series longer than 9 timepoints, last 3 points are weighted in the fitting so that changes in tendencies are well captured by the model.

(6) Estimating non-diagnosed cases

Lethality of Covid-19 has been estimated at around 1 % for Republic of Korea and the Diamond Princess cruise. Besides, median duration of viral shedding after Covid-19 onset has been estimated at 18.5 days for non-survivors[8] in a retrospective study in Wuhan. These data allow for an estimation of total number of cases, considering that the number of deaths at certain moment should be about 1 % of total cases 18.5 days before. This is valid for estimating cases of countries at stage II, since in stage I the deaths would be mostly due to the incidence at the country from which they were imported. We establish a threshold of 50 reported cases before starting this estimation.

Reported deaths are passed through a moving average filter of 5 points in order to smooth tendencies. Then, the corresponding number of cases is found assuming the 1 % lethality. Finally, these cases are distributed between 18 and 19 days before each one.

[7] At this moment we are testing predictions at 4 days for countries with more than 100 cumulated cases for 13-15 consecutive days, and 5 days for 16 or more days.

[8] Zhou et al., 2020. Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study. The Lancet; March 9, doi: 10.1016/S0140-6736(20)30566-3